FEBRUARY • 1955

SAVE TIME
In Vacuum Vessel Design
See Page 100

PETROLEUM REFINER

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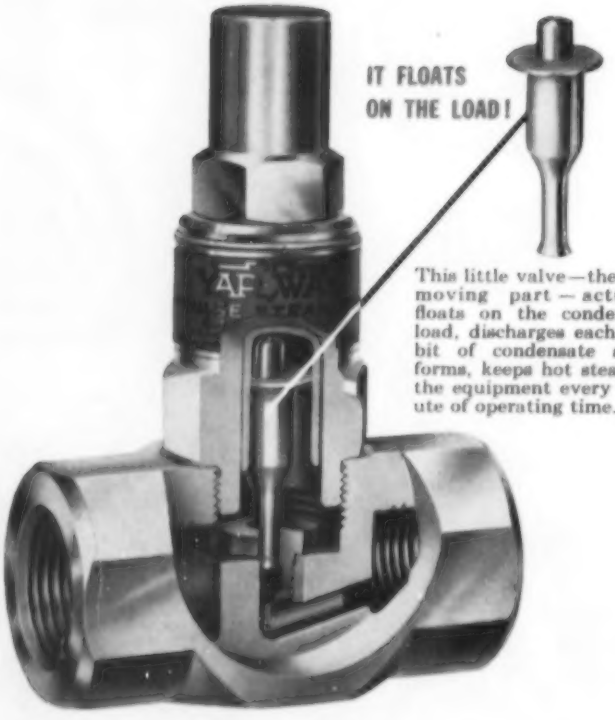

This little valve—the only moving part — actually floats on the condensate load, discharges each tiny bit of condensate as it forms, keeps hot steam in the equipment every minute of operating time.

YARWAY impulse® steam trap

Volume 34, No. 2 February, 1955

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A Quick Look at This Issue

Busy oil men can put first things first by scanning Quick Look's handy digests and checking ✓ those they want to read first

☐ **Save Time in Vacuum Vessel Design . . .** Here's a time-saving chart for determining the required wall thickness for a pressure vessel subjected to external pressure. Since most such vessels are designed for 15 psi external pressure (full vacuum), the author has constructed a direct-reading chart for this pressure, thus eliminating the usual time-consuming trial and error procedure. The chart can also be used for checking existing vessels. **Page 100.**

☐ **New Developments in the Alkylation Process . . .** The trend to high octanes along with the constantly increasing quantity of isobutane, propylene, and butylene from high severity cracking and reforming gives the alkylation process increasing importance in converting these gases into high quality fuels. The author reviews the alkylation process, describes the new Cascade reactor, and compares new alkylation plant designs with earlier designs. **Page 103.**

☐ **Polyethylene—Petrochemical Prodigy, Part 1 . . .** This product of the petrochemical industry has established an amazing growth record. Here is the first of a two-part series tracing this growth and outlining the factors that make it one of the brightest spots in the industry. In spite of severe reaction conditions required for its production, companies are eager to get into the market because of the versatility of this product. **Page 107.**

☐ **Boiling—Outside Finned Tubes . . .** Under certain boiling conditions, finned tubes compared to plain tubes can be used to advantage because of the large external heat transfer area. As you will discover in the data presented in this article, these conditions exist if the fin side coefficient is lower than the inside coefficient; the length of finned tube required for a given heat duty requirement is less than the corresponding plain tube required. **Page 113.**

➔ Turn the Page ➔

A Quick Look at This Issue

☐ **How Stresses Affect Branch Connections . . .** The installation of an unreinforced branch connection in a pipe results in stress concentrations of an unknown degree. This problem is closely related to that of openings in pressure vessels. The authors present basic data on the magnitude of these stresses in their report of a research program conducted at Battelle Memorial Institute. **Page 117.**

☐ **New Design Method for Vent Lines . . .** Here is a new solution to an old problem. The authors present a rigorous design method for real, rather than ideal, gases that offers considerable promise. Many of the former "simplifying assumptions" are no longer required. **Page 121.**

☐ **How Stable Are Shale-Oil Gasolines? . . .** Cracked shale-oil gasoline was found to be extremely unstable during storage. Large quantities of gum were formed in relatively short periods. Here are results which show how unstable this gasoline is and the effectiveness of several different inhibitors for preventing this gum formation. **Page 124.**

☐ **Thermal Cracking of Cat Naphtha . . .** If you have spare thermal capacity, here's a way to use it and get a better gasoline balance. The pilot studies outlined in this article show that the cracking of cat naphtha produces a higher yield of a higher octane gasoline than can be obtained from a comparable straight run naphtha. **Page 127.**

☐ **Making Aldehydes from Petroleum, Part 2 . . .** The discussion of the various routes for producing aliphatic aldehydes in petrochemical plants is continued from Part 1. The Oxo process, aldolization and aldol conversion, and partial oxidation of hydrocarbons all receive comprehensive treatment. **Page 129.**

☐ **Vapor Equilibrium Constants for Benzene . . .** The rapidly increasing installation of commercial facilities for the manufacture and recovery of benzene has intensified the search for fundamental physical and chemical data on this compound. This article presents hitherto unpublished data on the vaporization equilibrium constants, including those at higher temperatures and pressures. **Page 137.**

☐ **Save Your Steel Tanks . . .** Here's a discussion of the application of cathodic protection to steel storage tanks. The author discusses sources of current for cathodic protection, and the various types of anodes available. **Page 140.**

☐ **The Solubility of 1-Butene in Water . . .** There's great variability in the solubility of hydrocarbons in water. The solubility of 1-Butene in water is four times that of *n*-butane in water. Here are experimental data at pressures up to 1000 psia which may be used in the design of process units for the separation of butane-butene mixtures. **Page 143.**

☐ **Pure Aromatics from Cracked Naphtha . . .** While the recovery of nitration-grade aromatics from saturated feedstock is not news, their recovery from unsaturated cracked naphthas of various types is. Here are test results spelling out the techniques used and giving the yields and purities obtained. **Page 145.**

☐ **Higher Ketones as Dewaxing Solvents . . .** Some ketones show better performance as dewaxing solvents than the usual MEK-aromatic mixtures. The article reports the results of both applied research and actual plant operations of Imperial Oil's Sarnia plant. For some valuable and heretofore unpublished data on lube oil processing, turn to **Page 150.**

☐ **Consider Infrared for Gas Analysis . . .** Analyzers are now becoming available for continuous analytical instrumentation on the process stream itself. In this article you will find out all about the advantages and disadvantages of using infrared spectrometers for light hydrocarbon gas analysis. **Page 155.**

☐ **How to Test Fractionators—Part 2 . . .** The first article in this two-part series described practical methods for insuring that you are getting the maximum performance from your precise fractionators. The concluding part adopts the same approach for crude fractionators, and includes the results from actual plant tests. You are certain to profit dollar-wise from a careful study of this important work. **Page 159.**

☐ **Fringe Benefits Can Break You! . . .** The present cost to the petroleum industry is $1178 per year per employe. And the end is not in sight. For a sharp appraisal of a problem that it greater than you probably think, turn to **Page 98.**

☐ **Engineers' Registration: Why and How . . .** Industrial organizations are becoming more alert to the value of having registered engieners in their employ. Here's how an engineer should go about obtaining licensure. **Page 179.**

☐ **Make the Most of Your Meetings . . .** The prime paradox in American free enterprise is that individual initiative is made and managed by group action. The great institution of conventioneering has solid value in education, sales and growth. But this profit must be planned to be reaped. Turn to **Page 180** and find out how.

☐ **Credit Unions Are Big Business . . .** There are 298 operating credit unions in our industry with a total asset listing of $59,194,074. How did they begin? Are they good or bad? What is management's opinion? See **Page 187.**

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Single copies 50 cents (except special issues) for U. S. and Canada; $1 for all other countries. Subscription rates—U. S. and Canada $2 a year; Latin America and overseas $5 a year. PETROLEUM REFINER, published on the 13th of every month, entered as second class matter June 16, 1923, at the post office at Houston, Texas, under act March 3, 1879. Subscriptions restricted to those engaged in refining, natural gasoline or petrochemical industries or service and supply company personnel connected thereto. Advertising rates on application. Copyright 1955 by The Gulf Publishing Company. Cable address GULFPUBCO.

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Petroleum
REFINER in 1955

Here's Why:

MAINTENANCE

In March the spotlight will be on "Turnaround"—the single most important and most costly refinery maintenance problem. Coverage will be the most complete ever to appear in print, from when to have it to tightening the last bolt. Getting special attention will be ways of improving efficiency and decreasing costs.

API—NATURAL GASOLINE

In May a double-barrel issue that's loaded. A roundup of the best papers on timely refinery problems presented at the American Petroleum Institute's Refining Division annual meeting. Plus a symposium of the best articles on natural gasoline developments given at the annual meeting of the Natural Gasoline Association of America.

PROCESS

The process is the blueprint for procedure in all refining operations. This issue, an invaluable handbook for process men, will contain all the latest information on new and improved processes.

ALL THIS and more — much more — in 1955 in

Petroleum REFINER

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DM-2	2½% Cr.-1% Mo.	Sicromo 7	25-20*
Silmo	Sicromo 3	Sicromo 9M	25-12*
DM	4-6% Cr.-Mo.	18-8 Stainless	35-15**
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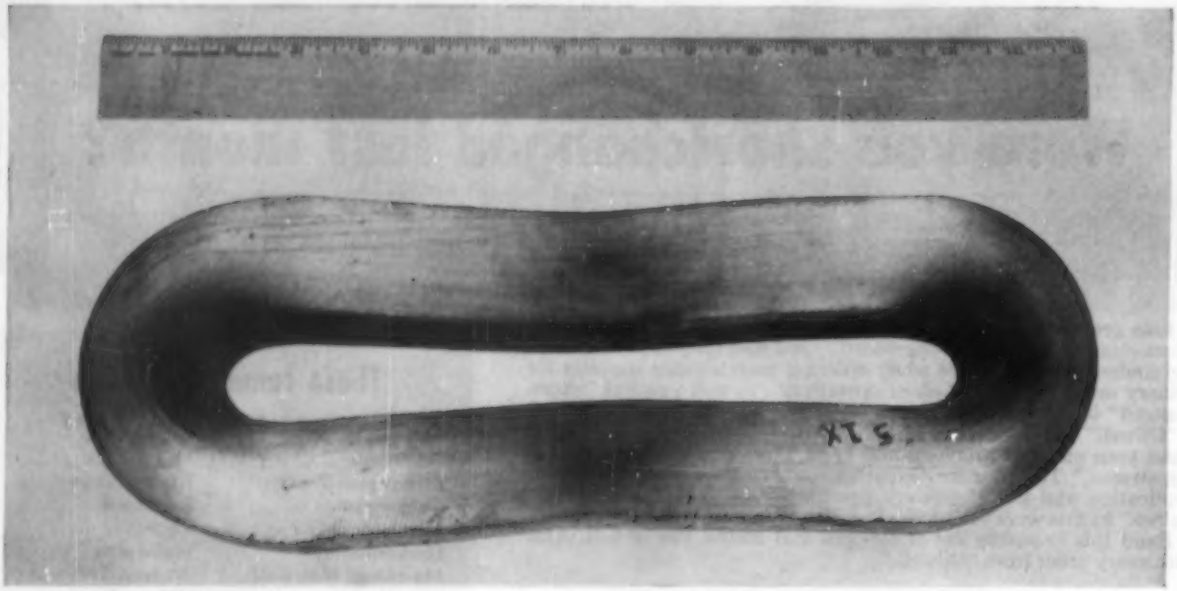

Flattened test of 10¼" O.D. by 1.580" wall of 18-8 Cb showing the excellent ductility of large, heavy-wall Timken seamless tubing.

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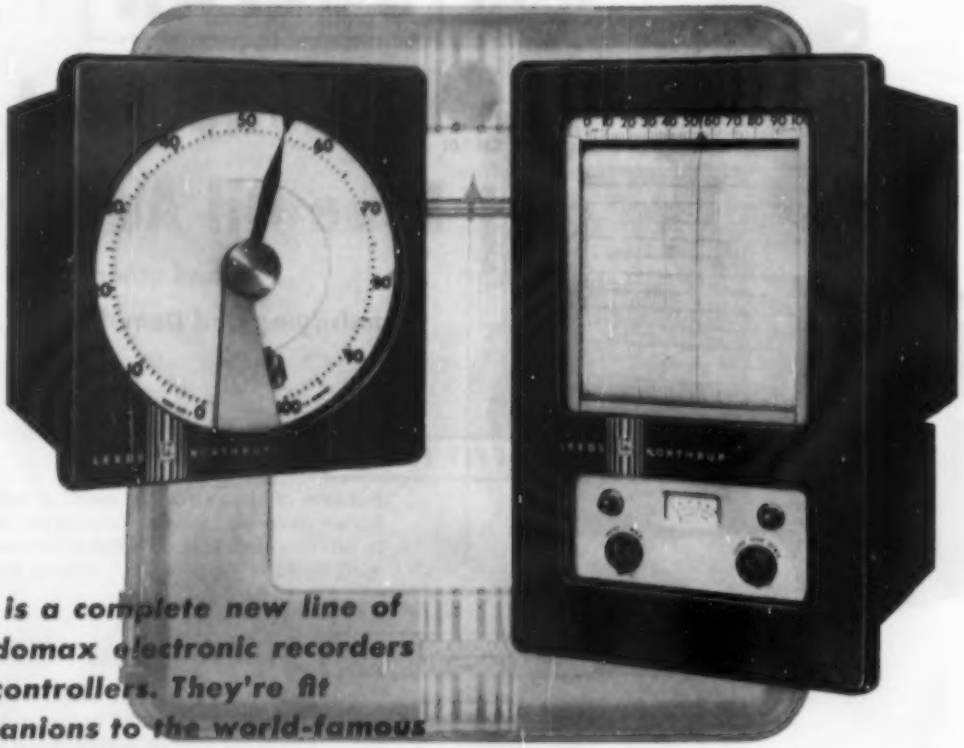

Here is a complete new line of Speedomax electronic recorders and controllers. They're fit companions to the world-famous Speedomax Type G. They are called Type H.

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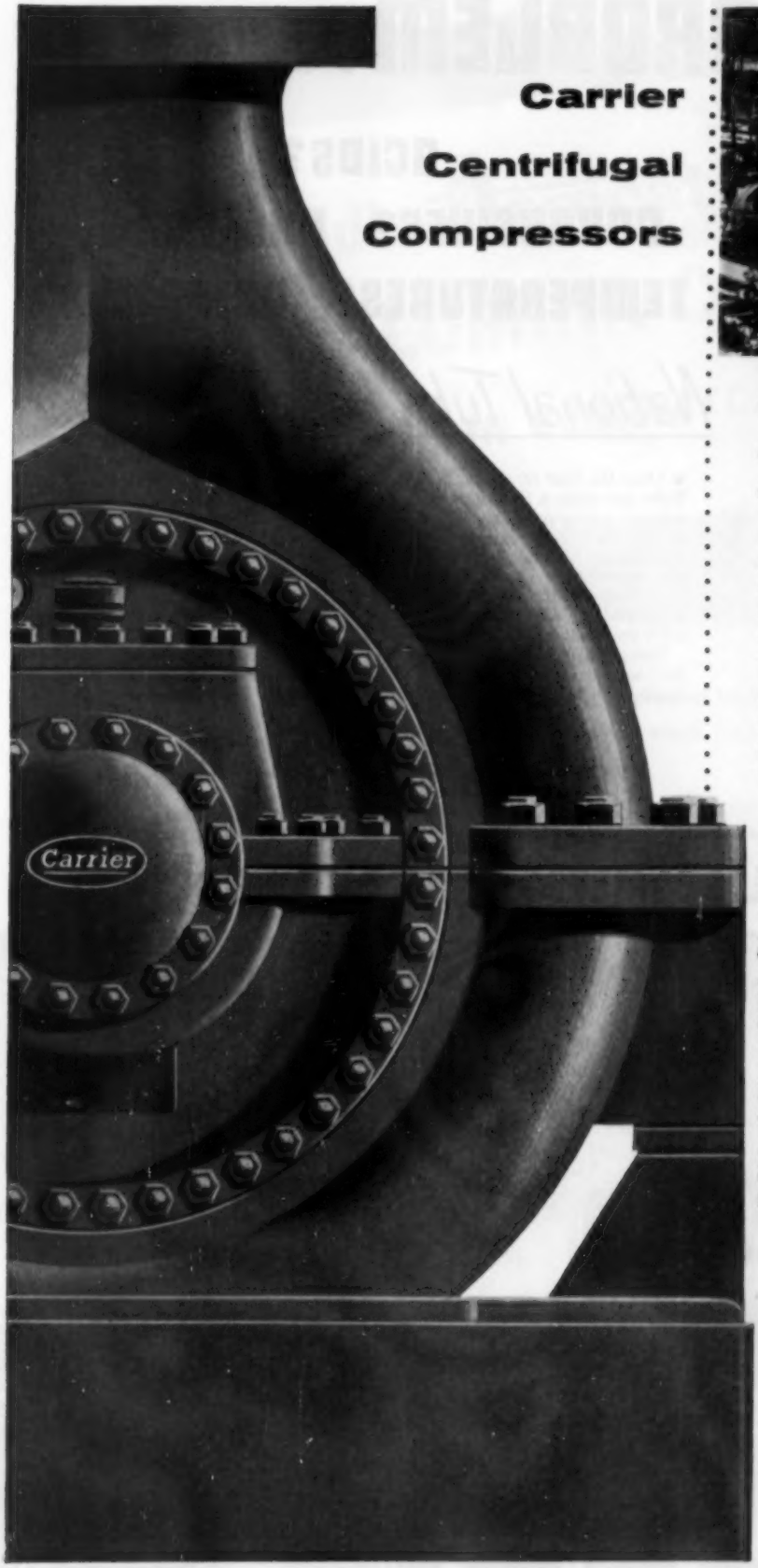

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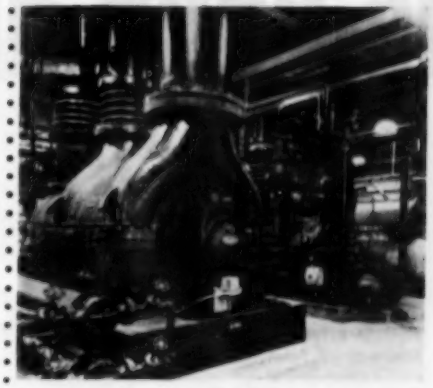

on the job at

Cities Service

Oil Company

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Carbon, ½ Mo	9 Cr, 1 Mo
½ Cr, ½ Mo	12 Cr
1 Cr, ½ Mo	12 Cr, Al
1¼ Cr, ½ Mo	17 Cr
2 Cr, ½ Mo	18-8
2¼ Cr, 1 Mo	18-8 Ti
2½ Cr, ½ Mo, ¾ Si	18-8 Cb
3 Cr, 1 Mo	18-8 Mo
5 Cr, ½ Mo	25-20
5 Cr, ½ Mo, 1½ Si	3½ Ni
7 Cr, ½ Mo	5 Ni
8 Cr, ½ Mo	

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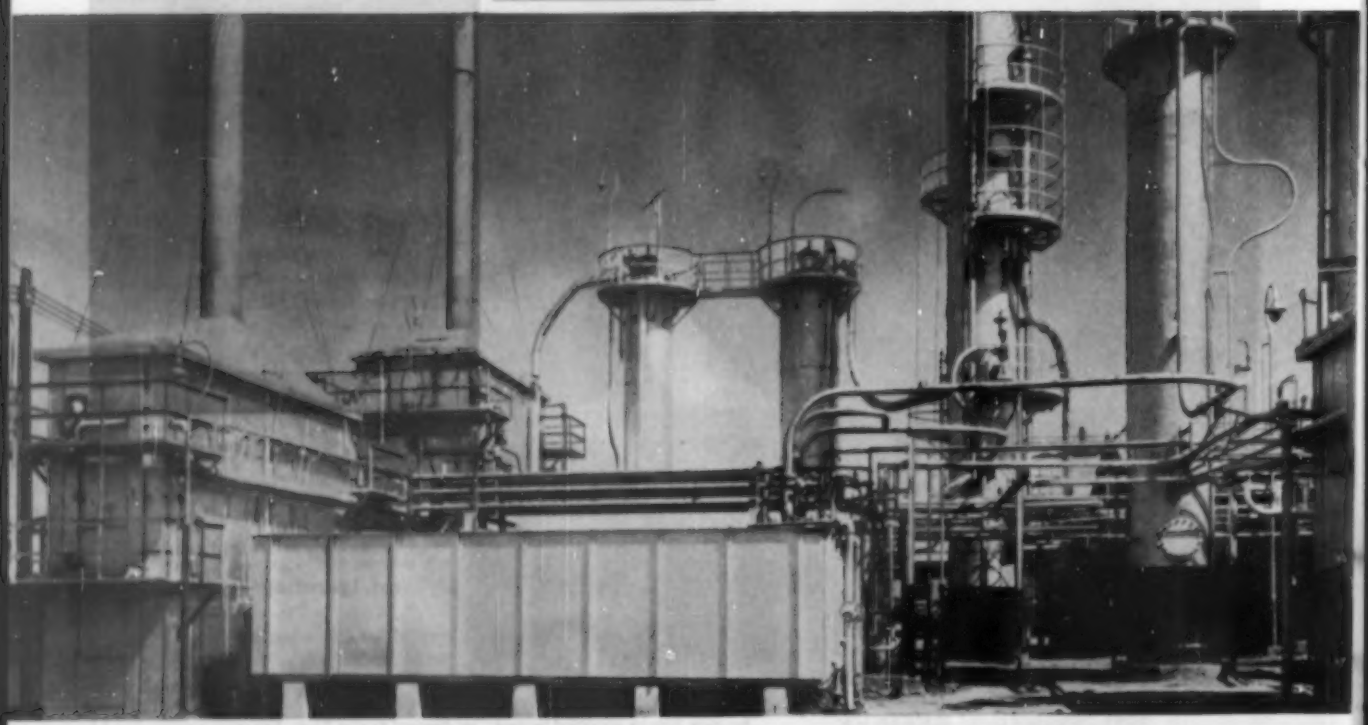


UNITED STATES STEEL

Cyanamid's Aerocat Triple A* HIGH ALUMINA CATALYST is now available in commercial quantities

The world's first commercially-proved High Alumina Catalyst (25%) offers superior activity stability, lower stack losses and excellent selectivity . . .

Cyanamid is pleased to announce that production facilities to manufacture AEROCAT TRIPLE A High Alumina Catalyst in commercial quantities have been completed. We are pleased, also, with the immediate and growing acceptance this important new catalyst has received from the refining industry.

AEROCAT TRIPLE A has an alumina content of 25% by weight. Laboratory research indicated this higher amount of alumina could be incorporated into fluid catalyst by special techniques so as to offer several important advantages over regular 13% alumina catalysts. These indications were fully proved by more than a year's successful trial performance in a commercial fluid unit at a major oil refinery. These advantages include:

Superior Activity Stability – AEROCAT TRIPLE A showed a consistent equilibrium activity 15-25% higher than 13% alumina catalyst. This means higher cracking efficiencies.

Lower Stack Loss – AEROCAT TRIPLE A gave a considerable reduction in the quantity of catalyst lost from the regenerator stack. For most operations, a reduction of 20% or more can be expected. This feature provides more effective retention of fresh catalyst additions and gives flexibility to withdraw and discard inactive or contaminated catalyst.

Excellent Selectivity – AEROCAT TRIPLE A gave product distribution equal to that of 13% alumina catalyst. With some feed stocks, tests have shown *improved* selectivity with Triple A.

By using AEROCAT TRIPLE A High Alumina Catalyst, you now have the money-saving choice of: (1) increasing output volume per ton of catalyst; or (2) improving performance at the same catalyst usage rate. Both mean lower catalyst cost to you.

Contact your Cyanamid representative for full details on this important new catalyst development.

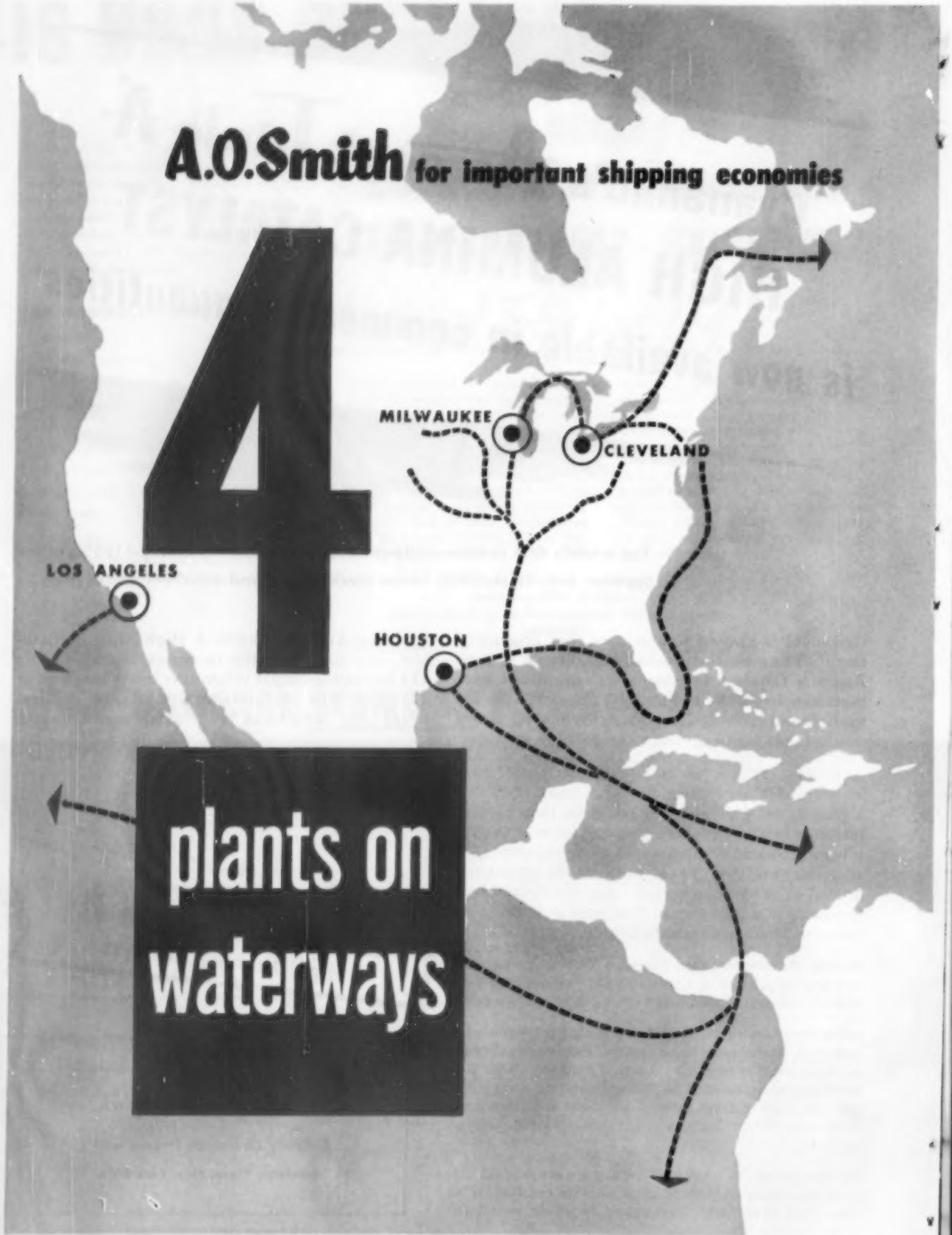
*Trade-mark

Aerocat Triple A*
High Alumina Catalyst

AMERICAN Cyanamid COMPANY
Refinery Chemicals Department
30 Rockefeller Plaza, New York 20, N. Y.

In Canada: North American Cyanamid Limited, Toronto and Montreal

For more data on advertised products, use Readers' Service Cards, last page.


A.O.Smith for important shipping economies
4
plants on waterways
MILWAUKEE
CLEVELAND
LOS ANGELES
HOUSTON

92,000-lb. synthesis converter being loaded for shipment at Milwaukee to Norsk Hydro Elektrisk Kvaelstofaktuselskat at Glomford, Norway. Featuring exclusive MULTI-LAYER construction, the unit is 40-ft. face to face, with 31½ in. ID and 3⅝ in. wall thickness. Designed to operate at pressures of 3556 psi.

Save on shipping costs . . . because our Milwaukee, Cleveland, Houston and Los Angeles vessel plants are located on waterways . . . because this provides for direct, economical transportation of large pressure vessels and heat exchangers to domestic and foreign ports. If your operations are near waterways, you can well imagine the advantages inherent in this strategic location of A. O. Smith manufacturing facilities.

Erection problems reduced . . . because waterway shipment permits delivery of fractionators, converters, accumulators, stainless and glass-lined reactors, as well as other larger vessels in one or, at most, two pieces. You can avoid field assembly costs . . . or, at least, reduce them considerably. The overall result is welcome economy in time and money.

Another good reason why it pays to see A. O. Smith first when you contemplate the purchase of pressure vessels and heat exchangers. We'd be glad to tell you about some of the other good reasons why it's good business to deal with A. O. Smith. Your letter to our Milwaukee office will bring a prompt reply.

Through research ...*a better way*

A.O.Smith

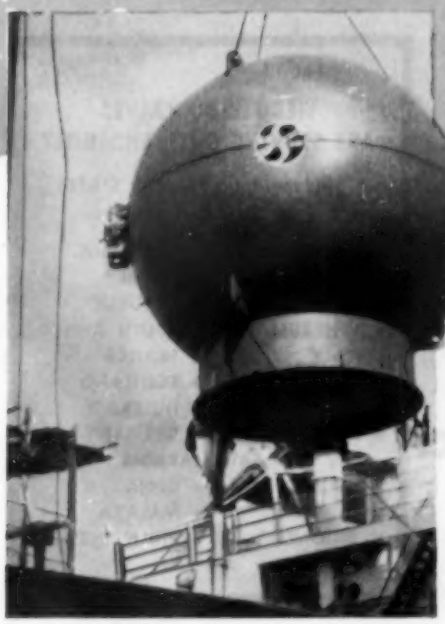
CORPORATION

PROCESS EQUIPMENT DIVISION

MILWAUKEE • HOUSTON • LOS ANGELES

International Division: Milwaukee 1

for glass-lined process equipment, contact GLASCOTE PRODUCTS, INC., Cleveland 17, Ohio an A. O. Smith Subsidiary.



This furfural digester, produced at A. O. Smith's Houston plant, is being loaded aboard a freighter for shipment to the South Porto Rico Sugar Trading Corporation, La Romana, Dominican Republic. Weight is 73,780 lbs. . . . diameter is 20 ft. . . . walls are 1-in. thick.

Weighing 181,200 lbs. each, these giant coking drums are being barge-loaded at Milwaukee for shipment to the Pure Oil Company's installation at Toledo, Ohio. Shipping route is up Lake Michigan, through the Mackinac Straits, along Lake Huron to Lake St. Clair . . . then to Toledo by way of the Detroit River and Lake Erie.

For more data on advertised products, use Readers' Service Cards, last page.

SAVING MONEY FOR USERS

WEDGEPLUG
NON-LUBRICATED
STEEL PLUG VALVES

...In Both HEMISPHERES

Wedgeplug Valves are scientifically designed so that the plug is lifted from its protected seats, makes a full 90° turn, and is reseated—all in one simple, conventional operation. **No lubricants are needed to free the plug from the body seats, or to seal the plug from leaking after operation.** Dependable performance, at a wide range of temperatures and pressures, has made Wedgeplug Valves an international favorite. **Write for the Wedgeplug Catalog.**

WEDGEPLUG VALVES ARE SERVING OUTSTANDINGLY

Throughout the UNITED STATES and CANADA, and in:

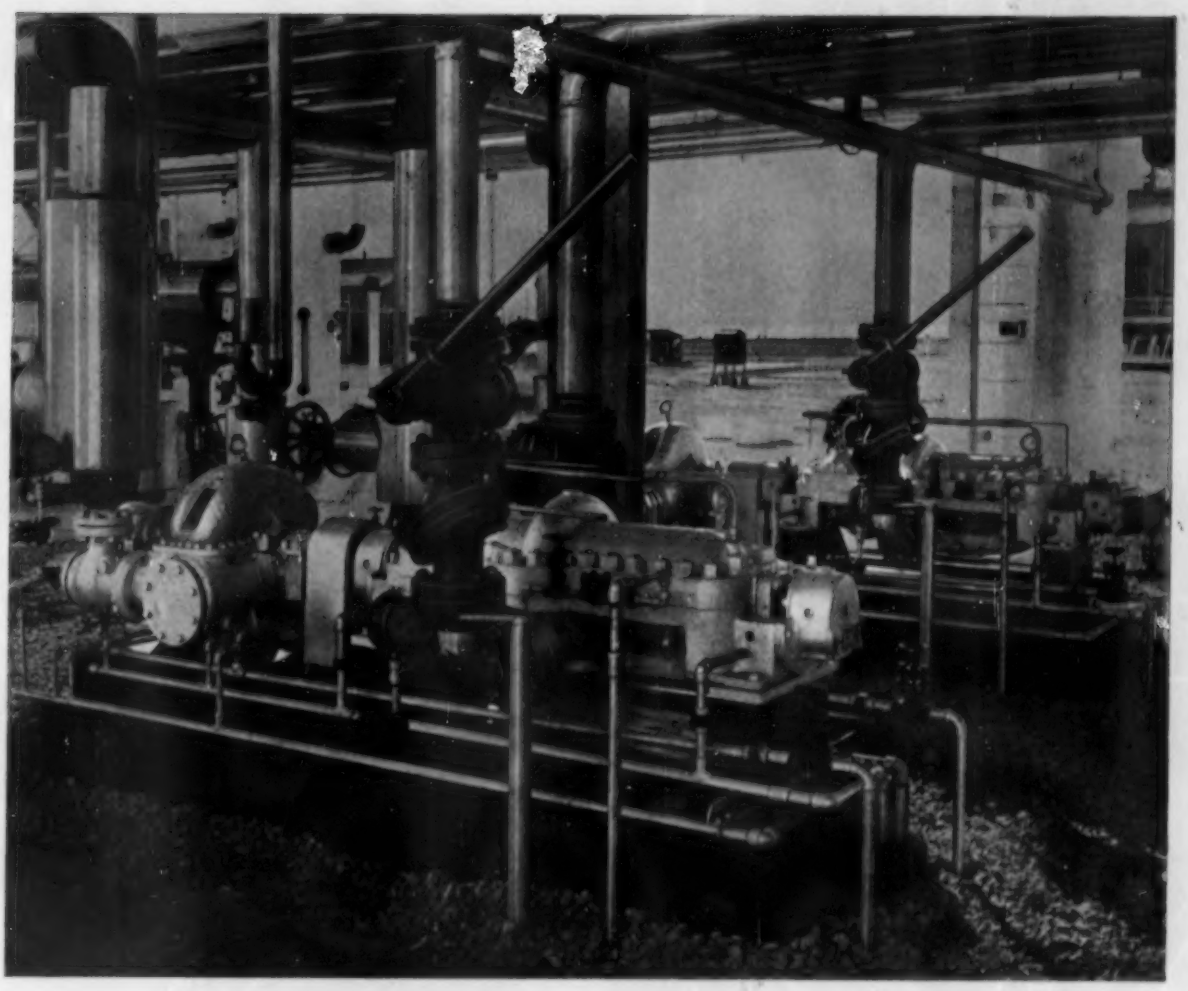
- MEXICO
- COLOMBIA
- ARUBA
- BRAZIL
- ARGENTINE REPUBLIC
- VENEZUELA
- SOUTH AFRICA
- ITALY
- FRANCE
- ENGLAND
- SCOTLAND
- WALES
- HOLLAND
- BELGIUM
- GERMANY
- SAUDI ARABIA
- IRAN
- INDIA
- JAPAN
- MALAYA
- INDONESIA
- PHILIPPINES

WEDGEPLUG VALVE COMPANY, INC.
NEW ORLEANS 25, LA.

An Affiliate of

STOCKHAM VALVES & FITTINGS
GENERAL OFFICES AND PLANT • BIRMINGHAM 2, ALA.

on deethanizer feed at PEGASUS PLANT



Ingersoll-Rand Pumps are giving efficient and dependable service at the Pegasus Plant in West Texas, operated by Magnolia Petroleum Company and built by Hudson Engineering Corporation. The two 2CNTA 8-stage steam-turbine-driven units shown above are on deethanizer feed service, handling 202 gpm of unstabilized gasoline of 0.515 specific gravity at 90°F. Suction pressure is 90 lbs. and developed head, 2155 ft. at 3500 rpm. Multi-stage Class CNTA pumps, with easily removable unit-type rotor assembly, are exceptionally well suited to refinery service involving pressures from 100 to 800 lb. and capacities from 50 to 700 gpm.

Other Ingersoll-Rand centrifugal pumps in continuous operation at the Pegasus Plant include many different units in a wide range of types, sizes and applications.

Consult with the I-R branch office near you for the solution of all your liquid moving problems.

Ingersoll-Rand

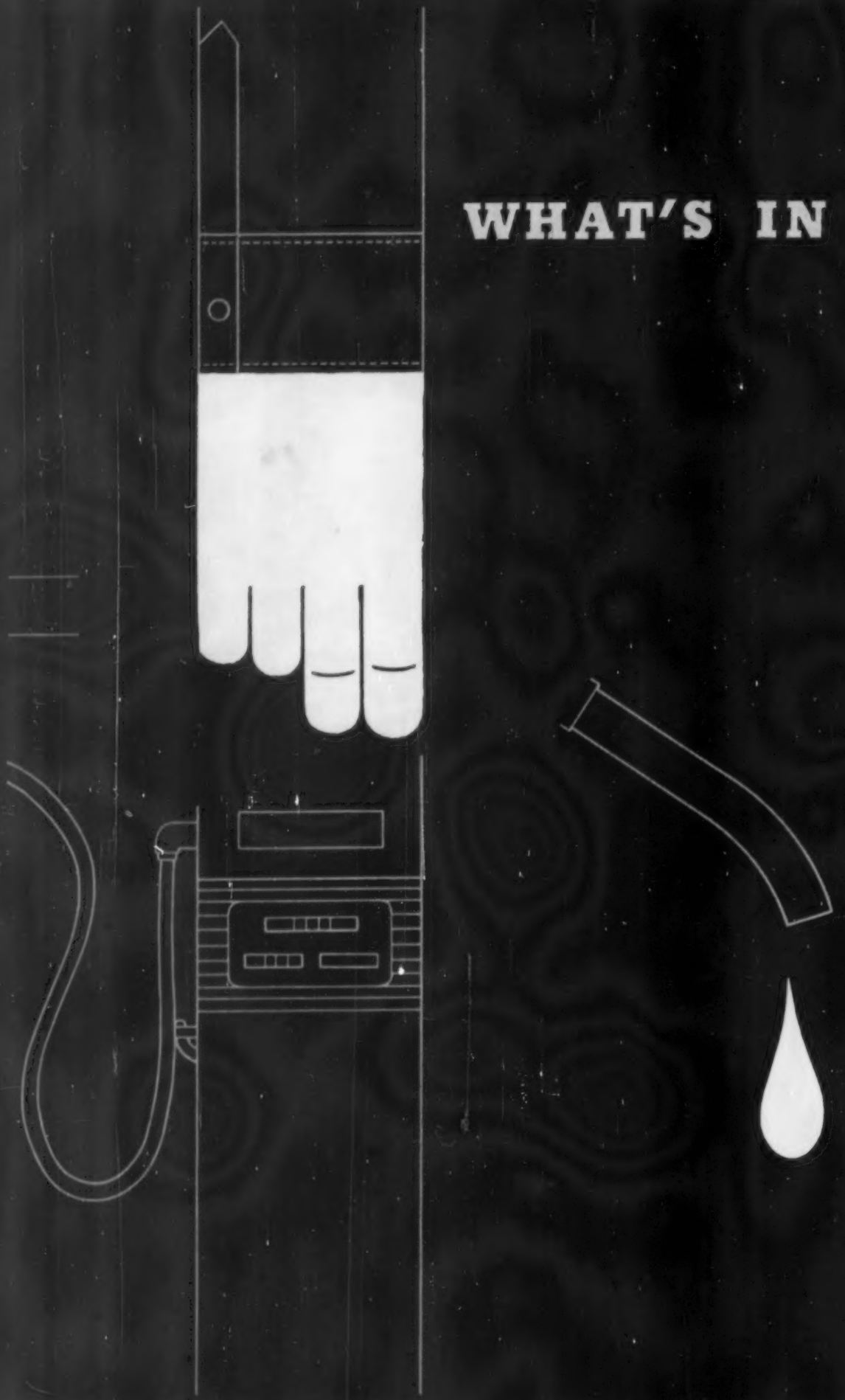
Cameron Pump Division
11 Broadway, New York 4, N. Y.

10-93

PUMPS • COMPRESSORS • TURBO-BLOWERS • VACUUM EQUIPMENT • AIR & ELECTRIC TOOLS • GAS & DIESEL ENGINES

For more data on advertised products, use Readers' Service Cards, last page.

WHAT'S IN IT



FOR YOU?

How do you . . . or any other refiner . . . benefit from the installation of the UOP Platforming process?

If you are among the many refiners who have Platformers, you will know the answer to these questions. For instance . . . you will know that Platforming provides an economical method by which you can raise the octane ratings of straight run, natural and thermally cracked gasolines efficiently and economically to conform to your marketing requirements. Likewise, you may know that Platforming enables you to produce benzene, toluene, xylenes, and other aromatics which are readily recovered in an extraction process. And you will also know of the many advantages you receive from operating under a license from Universal Oil Products Company because of its well-established service policies which assure you of top notch performance at all times.

Platforming is the pioneer catalytic reforming process which first used platinum catalyst. Because of the nature of the Platforming catalyst, its activity is maintained for long operating periods without regeneration, resulting in important economies. And the unusual simplicity of operation throughout the entire unit is responsible for further savings.

Gasolines made by the UOP Platforming process have proved their leadership among motor fuels. They meet and beat severe competition, and build gallonage in any market . . . on a most profitable basis.

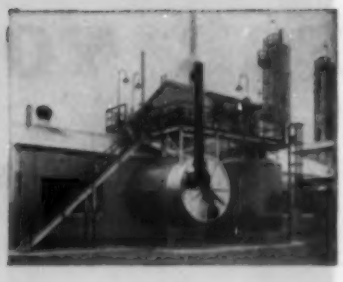
These are just a few of the advantages offered by this pioneer process . . . a few of the reasons why refiners the world over say, there's a lot in it for you.

UNIVERSAL OIL PRODUCTS COMPANY

UOP

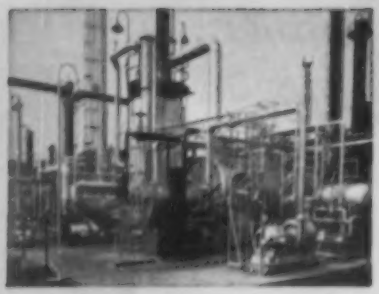
30 ALGONQUIN ROAD,
DES PLAINES, ILL., U. S. A.
Laboratories: RIVERSIDE, ILLINOIS

Universal Service Protects Your Investment



20

SULFUR PLANTS



by... **PARSONS**

75% of the contracts for plants to recover sulfur from H_2S in the United States and Canada during the past two years have been awarded to The Ralph M. Parsons Company.

Now under design for Tide Water Associated Oil Company on the East Coast is the largest sulfur recovery plant ever to be designed. This facility is expected to be on stream in 1956.

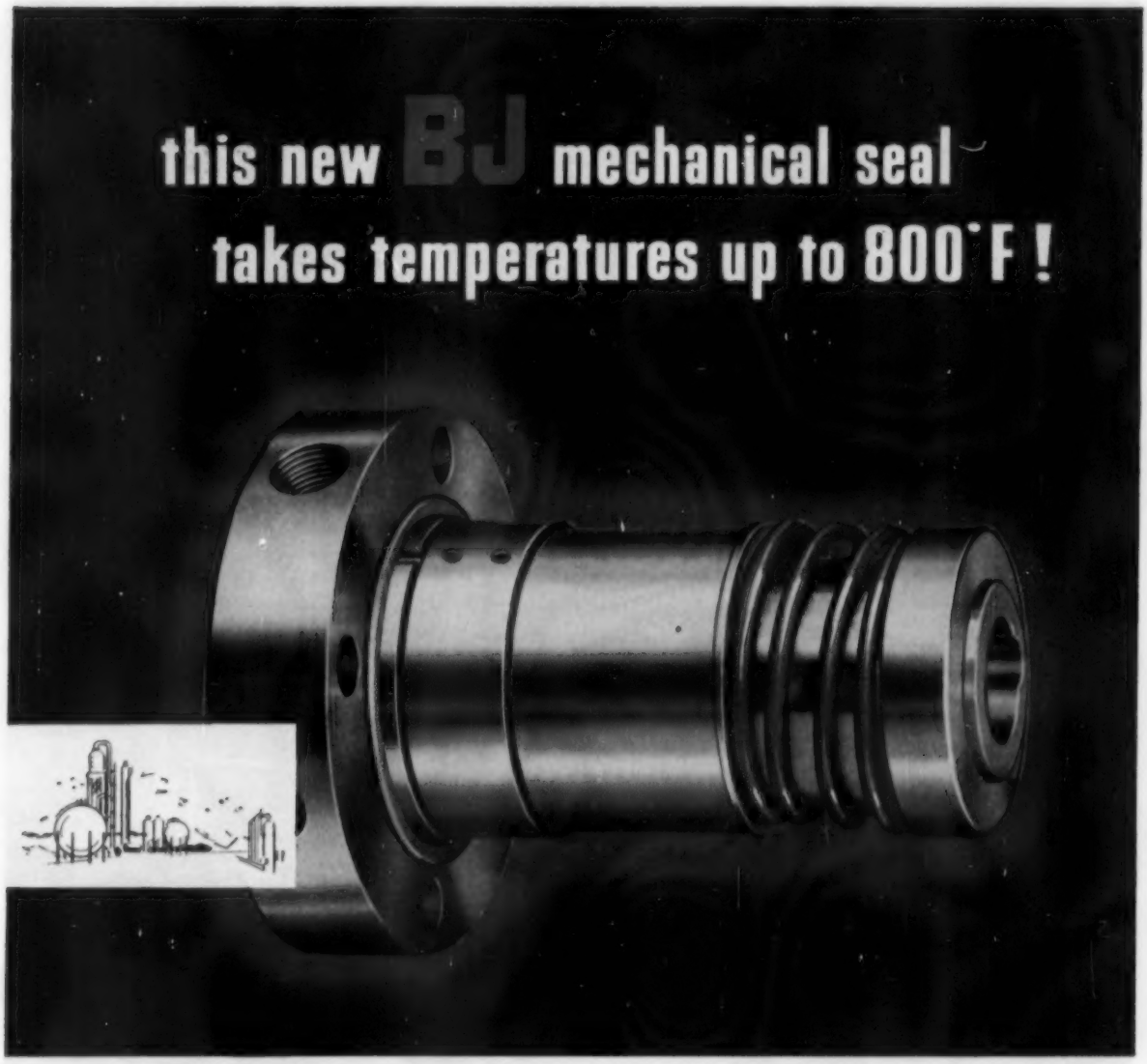
THE RALPH M. PARSONS COMPANY

Engineers • Constructors

617 South Olive Street, Los Angeles 14, California

NEW YORK • TULSA • WASHINGTON • ANKARA • BAGHDAD
BEIRUT • KARACHI • NEW DELHI • PARIS

this new BJ mechanical seal takes temperatures up to 800°F!



- **Proven in high temp refinery service**
- **No cold oil injection required**
- **No rotating face to sleeve gasket**
- **No stationary face to seal flange gasket**
- **Corrosion-resistant**

Here, at last, is a safe, effective answer to shaft sealing on high temperature, corrosive pumping service. This new Byron Jackson Mechanical Seal has been proved in rugged refinery service including hot asphalt and hot oil pumping (up to 800°F). It requires no cold oil injection, needs no auxiliary pumping for coolant. It is an all metal precision seal with no gaskets except shaft sleeve to shaft and seal cover to stuffingbox. New BJ High-Temp Seals are available now in any size and for any pressure encountered in refinery operation. Call your nearby Byron Jackson sales office for details or write.

You'll do better with BJ

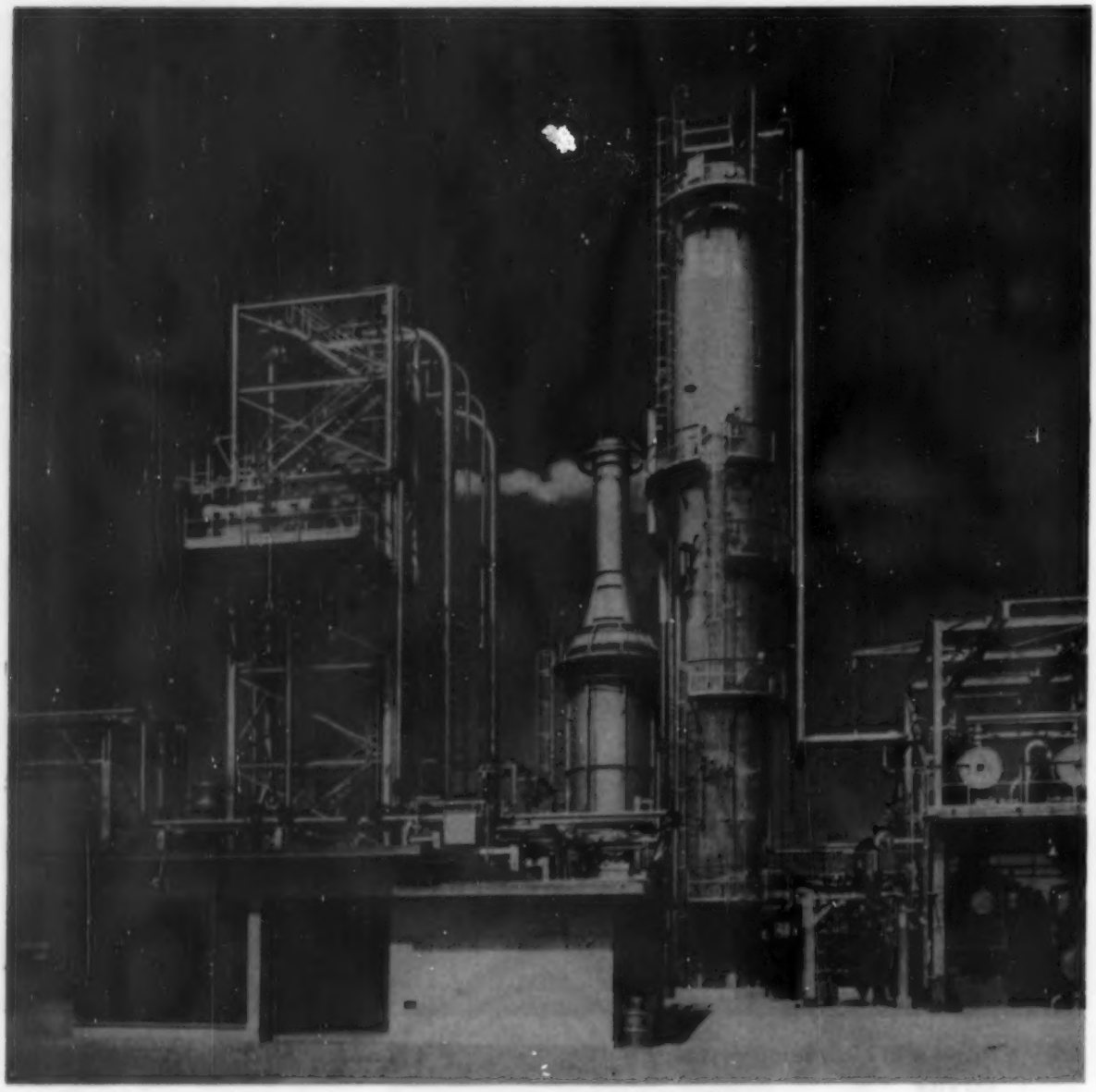
Byron Jackson Co.

PUMP DIVISION

Since 1872

P. O. BOX 2017, TERMINAL ANNEX, LOS ANGELES 54, CALIFORNIA

For more data on advertised products, use Readers' Service Cards, last page.



the Blaw-Knox Decarbonizing Process

. . . a better means for treating reduced crude . . .

helps McMurrey Refining boost profits

This new Blaw-Knox Decarbonizer, now on stream for several months, is increasing the McMurrey Refining Company's yield of valuable cat cracker charge stock from not-too-profitable residual fuel.

From 8000 BPSD of East Texas residuum, it is producing 7200 BPSD of clean gas oil and only 60 tons of coke per day.

The gas oil yield from the Blaw-Knox Decarbonizer is approximately 25 percent higher, and the coke yield about 50 percent lower than yields obtainable from conventional coking of the same charge stock. The Decarbonizer can be built for about two-thirds the cost of the conventional coking unit.

Blaw-Knox designed its Decarbonizing process with but one thought in mind . . . to help refiners profitably process residual fuels, and to do it with the least expenditure possible.

Let us put this thinking to work for you. Call on Blaw-Knox to engineer and construct all or any part of your project.

BLAW-KNOX COMPANY *Chemical Plants Division*
Tulsa 1, Oklahoma
Pittsburgh 22, Pennsylvania / Chicago 1, Illinois

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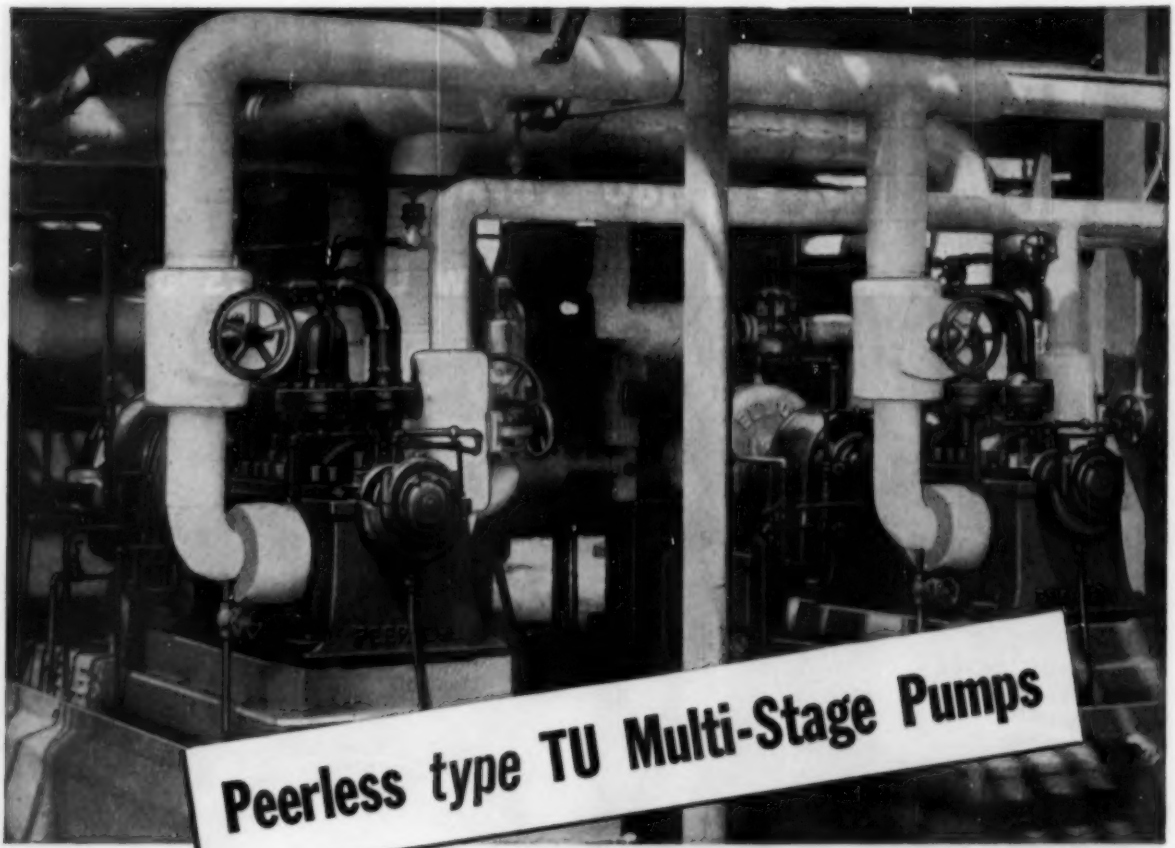


Peerless type TU Multi-Stage Pumps

PEERLESS PUMPS

GENERAL SPECIFICATIONS

HEADS	Up to 1600 Feet
CAPACITIES	Up to 3000 GPM
TEMPERATURES	Up to 300°F
CASE PRESSURES	Up to 800 Lbs.
HP RANGE	Up to 325 BHP
DRIVES	All Types
CONSTRUCTION	Cast Iron, Bronze, Stainless

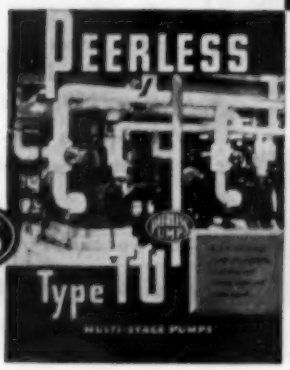
PEERLESS PUMP DIVISION
FOOD MACHINERY AND CHEMICAL CORPORATION

Address inquiries to Factories at:
Los Angeles 31, Calif. & Indianapolis, Ind.
Offices: New York; Chicago; Indianapolis; St. Louis; Atlanta; Plainview and Lubbock, Texas; Fresno; Los Angeles; Phoenix; Albuquerque, New Mexico.
Distributors in Principal Cities; Consult your Telephone Directory

PEERLESS PUMP — fmc

4 COST-SAVING FEATURES OF THE TYPE TU LINE

- *SIMPLICITY IN DESIGN*
- *GOOD HYDRAULIC CHARACTERISTICS*
- *DURABLE, RUGGED CONSTRUCTION*
- *ON-THE-JOB DEPENDABILITY*



2, 3, 4 AND 5-STAGE PUMPS FOR SUPPLYING CIRCULATING AND BOOSTING WATER AND PROCESS LIQUIDS AGAINST MEDIUM AND HIGH HEADS. Put these dependable pumps to work for you. They'll deliver high maintained efficiencies over an extended service life. Their split-case design makes them easy to service and maintain. Their precision construction guarantees year after year durability. In all sizes 4" and under, cross over between stages is built integral with upper pump case. Over-size shafts, wear rings, shaft sleeves, heavy duty ball bearings, modern case and impeller design are outstanding features. Choose from many types and sizes for all head and capacity requirements.

PROFUSELY ILLUSTRATED BULLETIN. A new 4-color bulletin describes the Peerless Type TU pumps. It's complete with pump cross-section, dimensional drawings and load-capacity data. Use coupon below.

MAIL COUPON FOR NEW BULLETIN

PEERLESS PUMP DIVISION
Food Machinery and Chemical Corporation
301 West Avenue 26, Los Angeles 31, California

Please send a copy of TU Pump Bulletin No. B-1400 to:

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

Pet. Ref.

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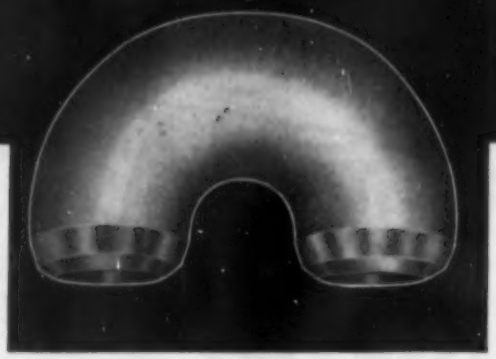
KEY-KAST

180° Turns Serve New Unifiners of...



EASTERN STATES PETROLEUM CO.

Finished in the record-breaking time of eight weeks, the new Unifiner of Eastern States Petroleum Co., Inc., Houston, Tex., is producing at a capacity even greater than anticipated—a tribute to the skill of the men who designed and built it, and to the quality of the materials used in its construction.

KEY-KAST 180° weldable U-bends were selected to serve the piping system of this efficient new Unifiner. More and more refineries, in fact, are specifying KEY-KAST fittings because KEY-KAST offers these outstanding advantages:

- Greater wall thickness throughout — for increased structural strength
- Extra thickness in critical areas — for greater allowance against erosion
- Lower unit cost
- Meet A.S.M.E. and A.S.A. Codes
- Rigid testing and inspection to meet high standards of quality

There's a Key-Kast fitting for every alloy piping need. Write for complete information.

Key company

Since 1916 . . . manufacturers and developers of products for high temperatures and pressures

Box 494-E, EAST ST. LOUIS ILLINOIS

DISTRICT OFFICES: NEW YORK • CLEVELAND
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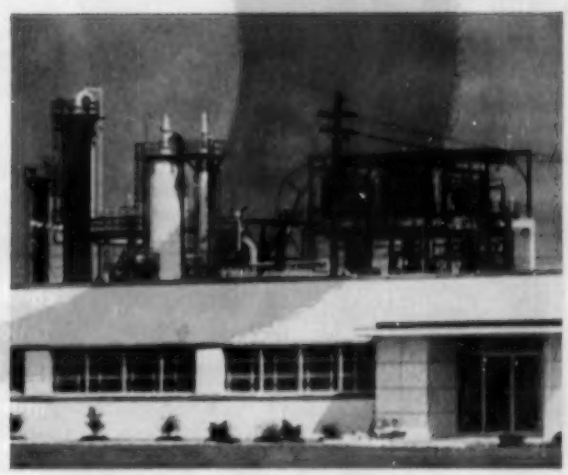
HERE ARE

Ethanolamines

of

Unsurpassed

Purity



Here is one of industry's brightest new plants —stainless steel towers and tanks, spotless piping at Nitrogen Division's new Orange, Texas, plant— to produce the highest purity Ethanolamines ever made in commercial quantities.

Shipment is made in tank cars directly from plant. Stocks are maintained throughout the country for delivery by tank truck and 55-gallon drums.

Ask for samples and quotations. Technical service is yours for the asking at no obligation. Call or write today!

- Anhydrous Ammonia
- Ammonia Liquor
- Ammonium Sulfate
- Sodium Nitrate
- Methanol
- Ethanolamines
- Ethylene Oxide
- Ethylene Glycols
- Urea
- Nitrogen Tetroxide
- U.F. Concentrate—85
- Formaldehyde
- Nitrogen Solutions
- Fertilizers & Feed Supplements

NITROGEN DIVISION ALLIED CHEMICAL

NITROGEN DIVISION

ALLIED CHEMICAL & DYE CORPORATION

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Hopewell, Va. • Ironton, Ohio • Orange, Tex. • Omaha, Neb.

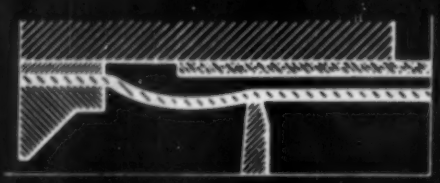
For more data on advertised products, use Readers' Service Cards, last page.

Solve FREEZING Problems with S&J "TITE-SEAL"

The Shand & Jurs "Tite-Seal" Breather Valve, illustrated here, is the practical answer to breather valve freezing problems. It incorporates a unique pallet design for both pressure and vacuum relief valves. The design utilizes a pliable diaphragm which provides the tightest possible seal through a novel balancing action. When venting, this diaphragm design provides a peeling action between the pallet and the seat, that overcomes sticking or freezing to a very marked degree.

The "Tite-Seal," Fig. ST-7575, is supplied with pliable, reinforced, synthetic rubber coated diaphragms for moderate climatic conditions, and with special diaphragms of Teflon coated fiberglass for extreme freezing hazards. The latter has been tested by impartial laboratories, government agencies, and by independent research organizations, and has been found to require only ¼" of water beyond normal setting to break ice. Yes, S&J "Tite-Seal" is the answer to your breather valve freezing problems.

S&J "Tite-Seal" in action. Typical pallet shown at the right. In operation, tank pressure is directed through a port to a chamber outside the periphery of the seat but inside the periphery of the pallet. This produces a slight ballooning which effects a perfectly tite-seal at all pressures below that for which the pressure pallet of the breather valve is set to open.



Shand and Jurs Co.
BERKELEY 10, CALIFORNIA

NEW YORK
342 Madison Ave.

HOUSTON
M & M Bldg.

TULSA
Thompson Bldg.

CHICAGO
10409 S. Western Ave.

LOS ANGELES
714 W. Olympic Blvd.

REPRESENTATIVES:
SEATTLE: Nebar Supply Company, 3000 Western Avenue
MONTREAL: Lytle Engineering Specialties, Ltd., 360 Notre Dame St., W.
TORONTO: Lytle Engineering Specialties, Ltd., 85 Richmond St., W.
VANCOUVER: P. D. McLaren & Son, Ltd., 3277 Main Street
CARACAS: Sinclair Spence, C.A., Edificio Galipan
ENGLAND: Whessoe, Ltd., Sales: 25 Victoria St., London, S.W. 1
Whessoe, Ltd., Works: Darlington, County Durham

He tests his purchases...

Do you?

Before he parts with $24.95, he tests a fishing rod to see how it will perform when the big ones strike. Yet last year, his department spent more than $100,000 for a cooling tower — and *nobody* has ever found out how it will perform under peak conditions!

Only a test will tell. The simplest and most positive test procedure is outlined in a new Marley technical publication, "Test Your Tower". By applying this conclusive test, you *know* the difference between actual and specified performance . . . you *know* how close your tower approaches the "guaranteed" performance you paid for.

With "Test Your Tower", a minimum of effort, and very little apparatus, you can determine performance of any industrial cooling tower under actual operating conditions. Just ask your Marley representative in any of 50 cities for your free copy, or mail the coupon below.

MAIL COUPON TODAY

MARLEY

Founder-member of the Cooling Tower Institute

The Marley Company

Kansas City, Missouri

Technical Services Dept.
The Marley Company
228 W. Gregory Blvd.
Kansas City, Mo.

Please send me a copy of your new brochure, "Test Your Tower."

Name.....

Firm.....

Address.....

City..... State.....

For more data on advertised products, use Readers' Service Cards, last page.

Bingham

DOUBLE VOLUTE DOUBLE CASE "HI-PRESS" PUMP

UNSURPASSED FOR EXTREMELY HIGH PRESSURES HOT or COLD SERVICES

"DOUBLE VOLUTE" DESIGN PROVIDES HYDRAULIC RADIAL BALANCE OF ROTATING ELEMENT... NO "SIDE PUSH"... ELIMINATES WEAR AND SEIZURE

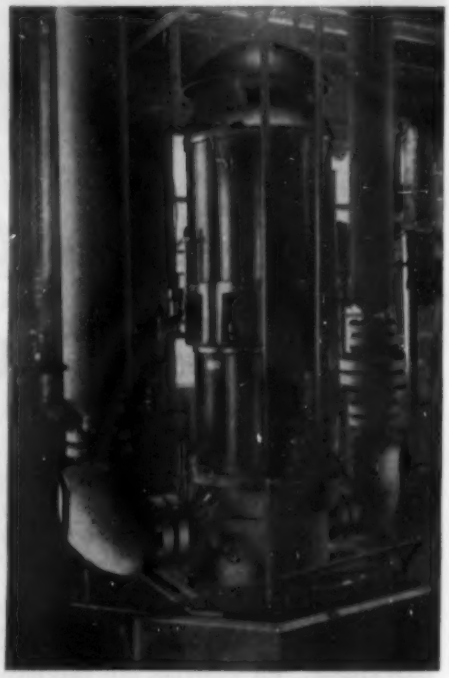
The "Double Volute" construction of Bingham Multistage "Hi-Press" Pumps insures perfect radial balance of the rotating element, under all operating conditions... completely eliminating wear between rotating and stationary parts. "Double Volute" construction permits maximum use, without exceeding normal clearances, of non-corrosive metallurgy—particularly austenitic steels—normally considered dangerous on account of their galling and seizing characteristics.

This feature also eliminates shaft deflection, permitting **mechanical seals** to establish and maintain a uniform track between contacting faces. This prevents leakage and seal face wear, resulting in **long seal life.**

"Double Volute" design also permits the pumpage to be discharged from the inner into the outer case through *two nozzles* located 180° apart. For hot service, this feature provides adequate circulation of pumpage between the two cases, insuring a uniform temperature rise in all parts—thereby eliminating distortion due to temperature changes.

Location of suction and discharge at top of pump case is particularly suitable for low NPSH conditions.

Bingham "Hi-Press" Pumps have established an exceptional record of long life and trouble-free service wherever they have been installed.



One of a group of Bingham "Hi-Press" Pumps in a large East Coast refinery handling 750° F. reduced crude oil at a differential head of 2000 feet.

Write your nearest Bingham office for full information.

Bingham SINCE 1921

DOUBLE VOLUTE PUMPS RADIAL BALANCE

BINGHAM PUMP COMPANY

General Offices: 2800 N. W. Front Avenue, Portland 10, Oregon

Factories: Portland, Ore. • Vancouver, B. C., Canada

SALES AND SERVICE OFFICES

BOSTON, MASS.	PITTSBURGH, PA.
CHICAGO, ILL.	SAN FRANCISCO, CALIF.
DENVER, COLO.	SEATTLE, WASH.
HOUSTON, TEXAS	ST. LOUIS, MO.
KANSAS CITY, MO.	ST. PAUL, MINN.
NEW ORLEANS, LA.	TULSA, OKLA.
NEW YORK CITY, N. Y.	TORONTO, ONT., CAN.
PHILADELPHIA, PA.	VANCOUVER, B. C., CAN.

Push-button Pipelines

Engineered and built by Gulf Interstate Engineering Company

You can now get a pipeline system designed to cut operating costs to a minimum. Gulf Interstate's new techniques and advanced designs actually reduce many operations to a matter of pushing buttons.

Gulf Interstate Engineering will contract to engineer, design or build these pipelines, compressor stations or allied facilities any place . . . any time.

Your inquiries are invited.

Gulf Interstate Engineering Company

GULF INTERSTATE BUILDING • HOUSTON, TEXAS

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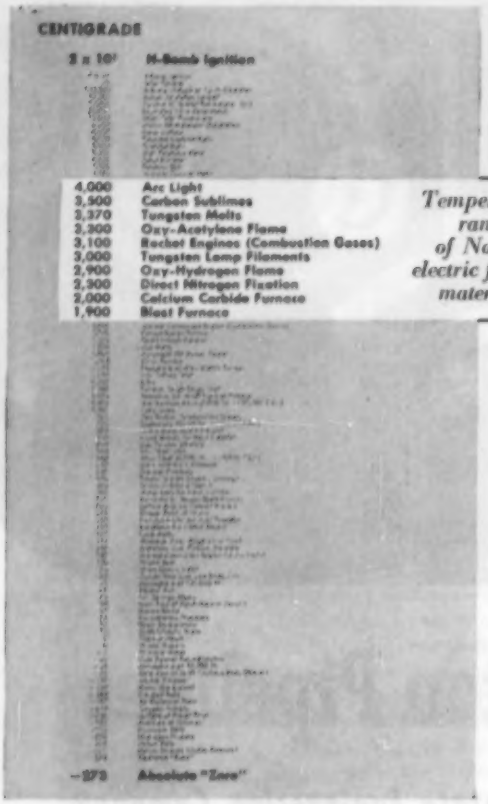
Norton materials for high temperature processing



Temperature range of Norton electric furnace materials

C° Melting Point	Temperature of Electric Arc Furnace 4000° C–7230° F	F° Melting Point
3540	ZIRCONIUM CARBIDE ZrC	6400
3300	FUSED THORIA ThO_2	5970
3140	TITANIUM CARBIDE TiC	5680
3060	ZIRCONIUM BORIDE† ZrB_2	5540
3000	BORON NITRIDE BN	5430
2900	TITANIUM BORIDE† TiB_2	5250
2700	FUSED ZIRCONIA ZrO_2	4900
2620	MAGNORITE* Fused Magnesia MgO	4750
2450	NORBIDE* Boron Carbide B_4C	4440
2300	CRYSTOLON* Silicon Carbide SiC	4170
2000	38 ALUNDUM* Aluminum Oxide Al_2O_3	3630
1900	REGULAR ALUNDUM Aluminum Oxide Al_2O_3	3450

Not True Color Temperatures

†Experimental Materials

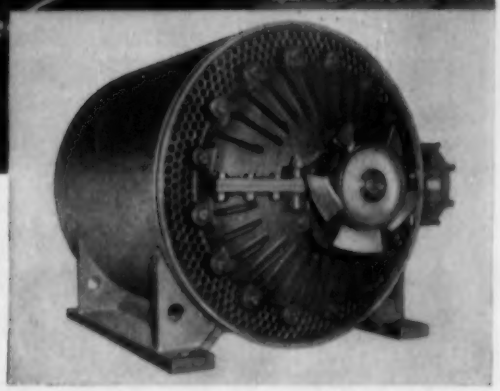
*Trade-Marks Reg. U.S. Pat. Off. and Foreign Countries

Are You Stymied by a "High Temperature Barrier?"

Are you concerned with industrial processing involving temperatures ranging upwards to 4000° C? If so, Norton Company has developed and is continually improving materials — produced and purified in electric arc and high temperature resistance furnaces — which may help you solve difficult technical problems. Norton Company supplies these materials in crude, processed or fabricated form — and will work with you in engineering them to your requirements. For further information, write to NORTON COMPANY, Refractories Division, 461 New Bond Street, Worcester 6, Mass.

Making better products . . . to make other products better

NORTON
REFRACTORIES
Engineered . . . Rx . . . Prescribed



3600-rpm explosion-proof motor with fan housing removed to show unidirectional fan.

These heat exchanger tubes

Protect this motor from dirt and corrosion

COOLING AIR is carried through the heat exchanger tubes with sufficient velocity to expel practically all kinds of dirt. If oily or sticky dirt should cling, tubes can be ramrodded clean on the spot in a few minutes because tubes are straight and tube ends are exposed. Also, the tubes are distributed uniformly around the perimeter of the stator yoke and along its full length — cooling all parts of the motor evenly.

Choice of Corrosion-resistant Materials

You can lick corrosion with this motor, too. Tubes are available in a variety of materials to meet practically any corrosive atmospheric condition. Allis-Chalmers tube-type motors have long and successful experience in such difficult applications as caustic plants, refineries and petrochemical plants, power plants with fly ash problems and many others.

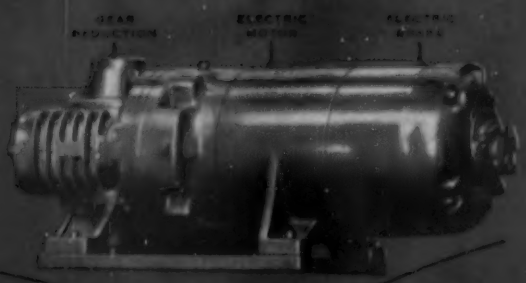
Get Complete Information

Next time you need a motor for a dirty or corrosive location or for outdoor operation in all kinds of weather, call your Allis-Chalmers District Office. Get complete information on Allis-Chalmers tube-type totally-enclosed, fan-cooled and explosion-proof motors. Or write Allis-Chalmers, Milwaukee 1, Wisconsin, for Bulletin 51B7149. Available in ratings on frames larger than NEMA 505 up to 3000 hp (labelled through 1250 hp, 1800 rpm).

A-4558

ALLIS-CHALMERS

For more data on advertised products, use Readers' Service Cards, last page.

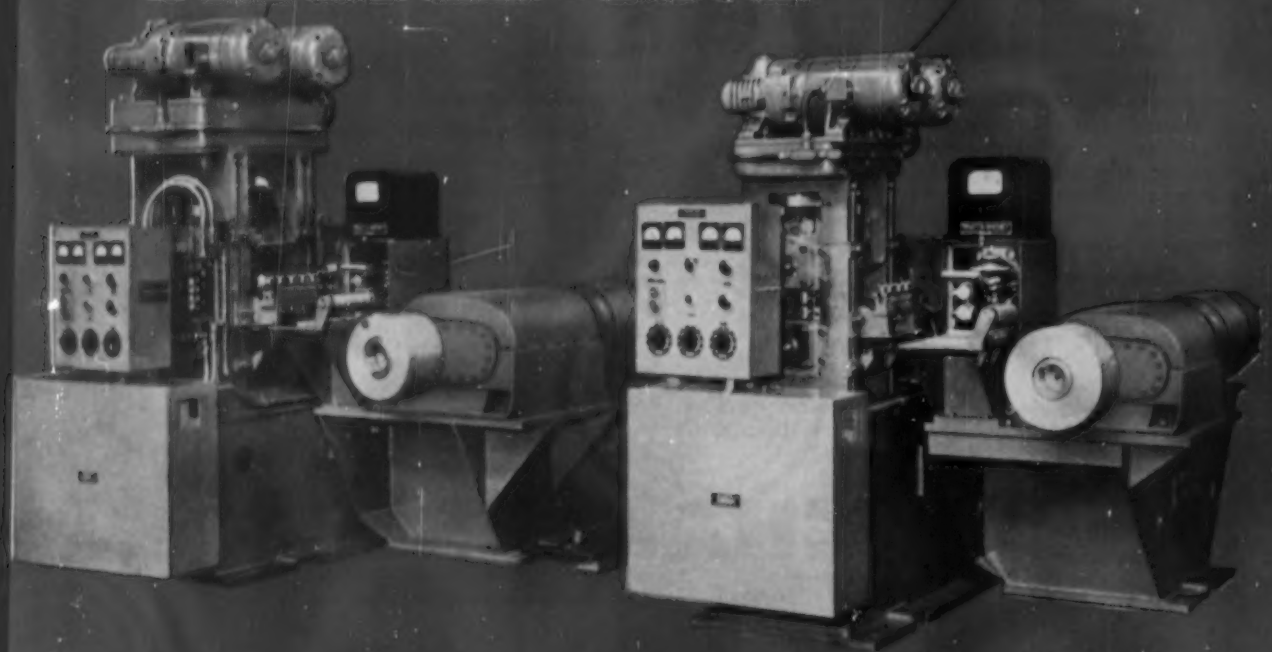


See how easily the standard electric motor, standard gear reduction, standard electric brake combine into a drive that gives the RIGHT horsepower, the RIGHT shaft speed, the RIGHT features . . . all in one compact unit. Nowhere else will you find power units that are so flexible, so easily adaptable, and in such a wide range of types and ratings.

Master power drives are available in thousands and thousands of ratings (1/8 to 400 HP) . . . in open, enclosed, splash proof, fan cooled, explosion proof . . . horizontal or vertical . . . for all phases, voltages and frequencies . . . in single speed, multi-speed and variable speed types . . . with or without flanges or other special features . . . with 5 types of gear reduction up to 430 to 1 ratio . . . with electric brakes . . . with fluid drive . . . with mechanical or electronic variable speed units . . . and for every type of mounting . . . Master has them all and so can be completely impartial in helping you select the one best power drive for you.

standard units easily combine into special purpose drives

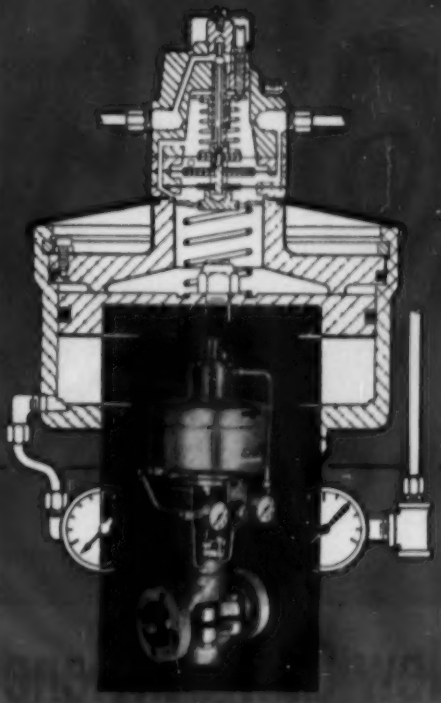
THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO



OUTMODES ALL OTHERS

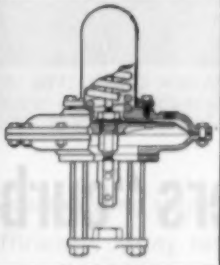
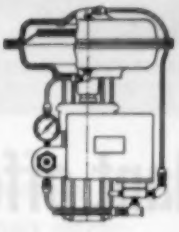
for Throttling Control Service

. . . CONOMOTOR SERIES LB VALVES



Conoflow is unbiased in evaluating the relative merits of the Cylinder Conomotor over spring-and-diaphragm and springless diaphragm motors. Conoflow makes all three. But look at the chart below . . . There's not merely an "edge", but a *wide margin* of superiority in the Cylinder Conomotor . . . in weight . . . in compact size . . . in speed of operation . . . stem travel . . . and thrust. No other operator surpasses it for positioning accuracy and stability of operation. Diaphragm breakage is eliminated and maintenance is greatly reduced. It's easy to convince yourself. Just try one or several . . . and you'll standardize right down the line on Conomotor Series LB Control Valves.

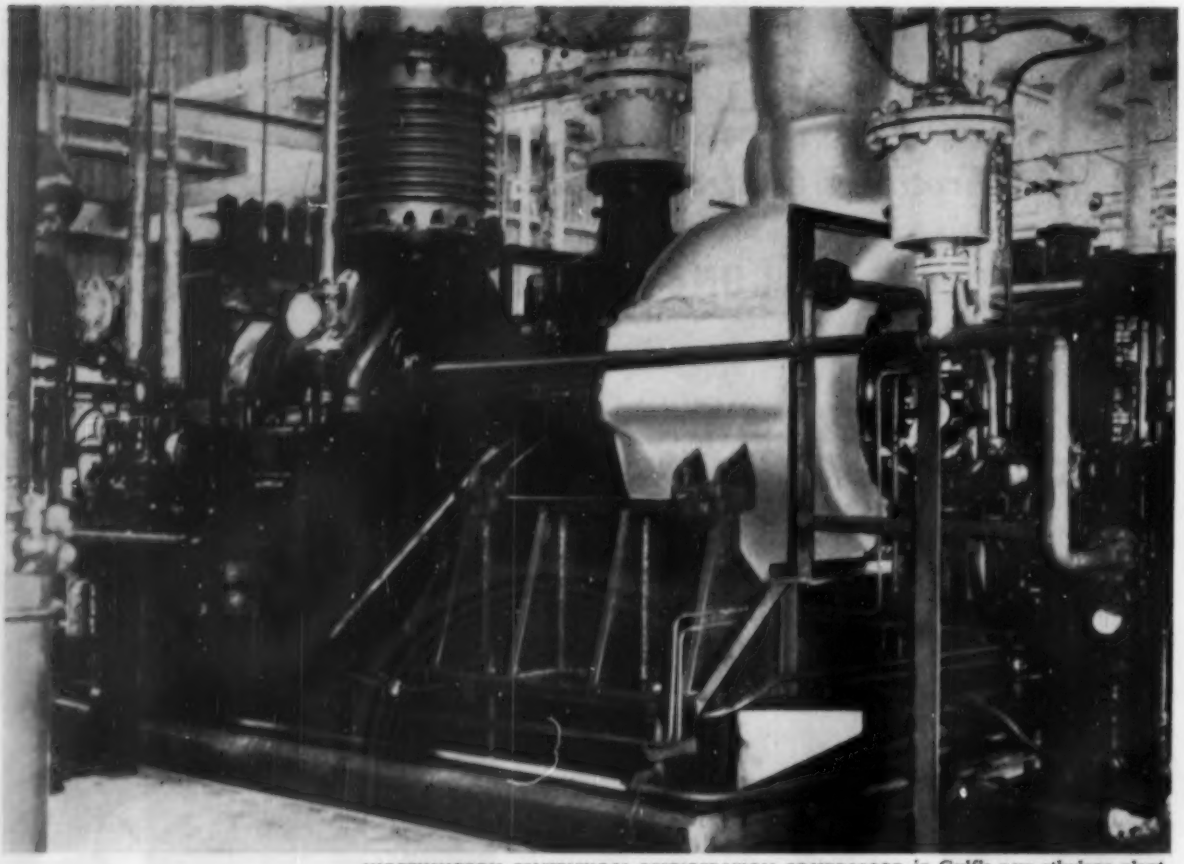
(COMPLETE DETAILS IN CATALOG LB-1)

Check these Points of Superiority in the CONOFLOW PNEUMATIC CYLINDER OPERATOR			
MODEL	B-10-TM Spring & Diaphragm Motor	B-12-T Springless Diaphragm Motor	B-53 Cylinder Conomotor
PISTON OR DIAPHRAGM AREA	← 50 square inches →		
THRUST	750 lbs.	1250 lbs.	4500 lbs.
STEM SPEED	12 seconds	10 seconds	4 seconds
TRAVEL	1"	1⅜"	4"
MAXIMUM SUPPLY PRESSURE	30 psi	30 psi	100 psi
WEIGHT	45 lbs.	45 lbs.	25 lbs.
SIZE	11¾" dia. 16¾" height	11½" dia. 14¾" height	9" dia. 14" height

Cono-Controls®

CONOFLOW CORPORATION

2100 ARCH STREET PHILADELPHIA 3, PA.



WORTHINGTON CENTRIFUGAL REFRIGERATION COMPRESSOR in Gulf's new ethylene plant. Nozzles are for interstage bleed which boost discharge flow to four times initial suction flow.

New Gulf ethylene plant offers "curb service"

HANDLING CHARGE GAS at Gulf plant keeps this Worthington centrifugal compressor busy. Water injection nozzles control temperature, prevent co-polymerization.

Gulf Oil's new 180 million pound-per-year ethylene plant at Port Arthur, Texas, is the first ever designed to deliver its products directly to consumers—some of them 80 miles away—*by pipe line!*

It's also the first to use centrifugal compressors (by Worthington) for charge gas compression, water injection for cooling to prevent co-polymerization and multi-nozzle compressors to accommodate large bleed-in loads.

Three Worthington compressors handle five different charge streams in the process. Two more provide the necessary refrigeration for the process. Power—19,850 hp in all—comes from five Worthington steam turbines and one gas expander.

For over 50 years Worthington has been helping petroleum and chemical processing men with knotty refrigeration problems. Check your Worthington district office about yours—or write Worthington Corporation, Air Conditioning and Refrigeration Division, Sec. A.5.30-PE, Harrison, N. J.

A.5.30-PE

WORTHINGTON

CLIMATE ENGINEERS TO INDUSTRY, BUSINESS AND THE HOME

where intolerance is a virtue!

Intolerance of salt in crude charging stocks is one of the first rules of refining efficiency. Many refiners advantageously desalt crude oils containing as little as 20 pounds per thousand barrels. With certain refining processes the salt tolerance is much lower. In general, the trend of permissible salinity is constantly downward.

Tretolite desalting removal percentages average between 95 and 100%, with many instances of 99 plus per cent removals. In spite of this excellent performance, the chemical cost of Tretolite desalting averages approximately 2 mills per barrel.

For complete information, ask the Tretolite refinery service engineer in your area or write to

TRETOLITE COMPANY

A DIVISION OF PETROLITE CORPORATION

369 MARSHALL AVENUE, ST. LOUIS 19, MISSOURI

5515 TELEGRAPH ROAD, LOS ANGELES 22, CALIFORNIA

These advantages of Tretolite desalting insure maximum desalting performance at minimum cost.

1. **Low equipment cost**
2. **Simplicity of operation**
3. **Flexibility of operation**
4. **Efficient solids removal**
5. **Minimum operating attention**
6. **High percentage salt removal**
7. **Clean effluent water**
8. **Always available service**

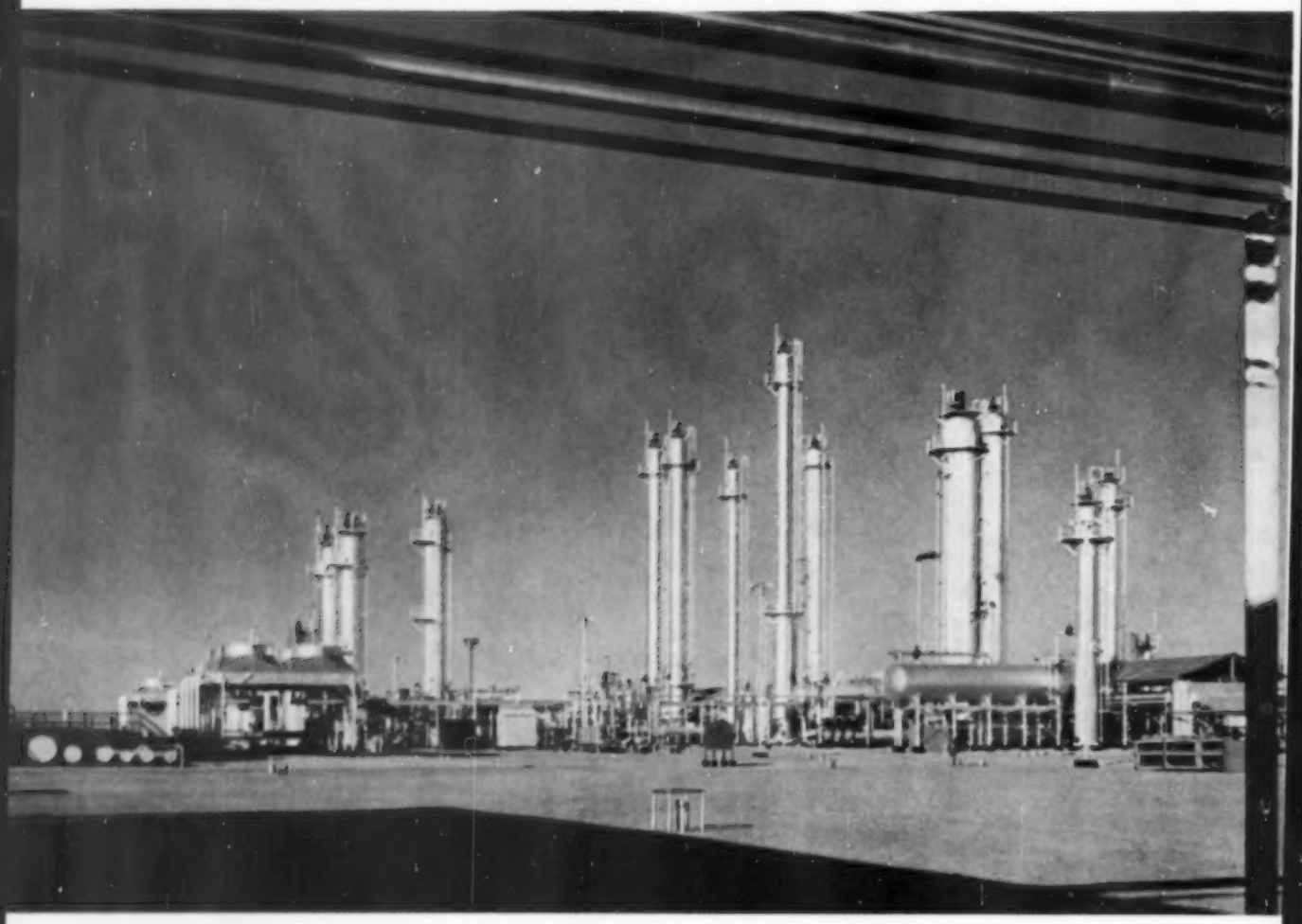
Chemicals and Services for the Petroleum Industry

DESALTING • CORROSION INHIBITING

DEMULSIFYING • SCALE PREVENTIVES

WATER DE-OILERS • ASPHALT ADDITIVES

TR 55-8



THE *Pegasus* GASOLINE PLANT

In the Pegasus field near Midland in West Texas HUDSON has completed the latest of SEVEN MAJOR PROJECTS for Magnolia Petroleum Company. These seven projects plus numerous smaller ones for the same client are typical of the work that has built the world-wide confidence of the oil industry in the ability of HUDSON to complete small or large processing plants in minimum time, with assured performance, and with minimum capital outlay consistent with low operating costs.

Repeat contracts with a long list of satisfied clients make up a large part of the more than 100 projects constructed by HUDSON in the last fifteen years.

DESIGNERS AND CONSTRUCTORS OF
OIL AND GAS PROCESSING PLANTS

HUDSON
ENGINEERING CORPORATION

FAIRVIEW STATION • HOUSTON, TEXAS

Safety at the L.P.G. loading rack — thanks to Rockwood Ball Valves

This Eastern loading rack runs no risk of gas seepage when trailer tankers are being filled. Rockwood Ball Valves are the reason why.

The quick opening and closing of these valves is a tremendous asset during loading. But of primary importance is the fact that Rockwood Ball Valves are *leakproof*.

These four exclusive features guarantee the trouble-free performance and efficiency of Rockwood Ball Valves —

Full Round Flow — no change in shape or volume of fluid stream — no turbulence — no minimum loss.

Quick Opening and Closing — only a quarter turn needed.

Longer Wear-Resistance — chrome-plated bronze ball withstands abrasion, pitting and scratching.

Leakproof Seal — pressure of fluid automatically positions ball against seat to form tight seal.

If you are not now using Rockwood Ball Valves, send coupon today for complete information. Valves come in all pipe sizes. Tested and listed by Underwriters' Laboratories, Inc.

ROCKWOOD BALL VALVES

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
562 Harlow Street
Worcester 5, Mass.

Send me illustrated folder V-4 on Rockwood Full-Flow Ball Valves.

Name_____

Title_____

Company_____

City_____

Zone_____ State_____

For more data on advertised products, use Readers' Service Cards, last page.

Natural gas producers, small and large, are convinced that if the American people understand the issues regarding federal regulation they will reach the right decision. Therefore, we are endeavoring to lay the subject before the people and to encourage the fullest possible discussion of the issues. To do so, this advertisement has been placed in newspapers throughout the country.

What the Regulation of Gas Supply Means to 25,000,000 American Families

THE FIVE THOUSAND producers of natural gas—large and small—believe that the free competitive system which has increased your gas supplies and kept rates low is the best for consumers, for the industry, and the economy.

They believe the proposal to abandon competition and clamp bureaucratic controls on gas production will hurt consumers, damage the industry, and *benefit no one*.

Here are some answers to questions you as a consumer may have on this vital issue.

What Is This Regulation?

Sixteen years after a 1938 law was passed, a new interpretation of some of its words now forces the Federal Power Commission to do what it has eleven times refused to do—try to fix the price that an interstate pipeline pays the 5000 competing producers who find the gas and get it from the ground.

Will This Regulation Reduce Our Gas Bills?

Hardly. Only about 10% of the average gas bill goes to the producer who finds the gas and sells it. The other 90% pays for constructing, maintaining and operating the long-distance pipelines and local distribution systems—already regulated.

How Will Regulation Affect Supply?

It will reduce the supply. Most natural gas is produced by "wildcatters" and other independents. They are used to keen competition and big risks. But put them under Federal controls—with permits, endless forms, licenses, hearings and suits—and the work of exploration is sure to suffer. Three new pipeline projects to bring gas to more consumers have been suspended since regulation took effect.

Hasn't Gas Always Been Regulated?

Gas *distribution*, yes. It makes sense to have only one pipeline bring gas to a community—and one gas company distribute it in the community. Both do a good, efficient job for you, and as monopolies they are naturally regulated.

But there's no monopoly in *finding* gas. Far from it. Gas *production* is risky and keenly competitive. There are five thousand large and small producers looking for gas—and finding it in only one out of

every nine exploratory wells they drill. They compete vigorously to sell their gas. A single pipeline may buy from 200 or more producers.

Is Gas Different from Coal or Oil —or Grain?

It isn't. And if there's price-fixing for natural gas at the well so can there be next for coal at the mine or oil at the well—or lumber in the forest, or grain on the farm.

How Did The Consumer Fare Before This Regulation?

Here's the record. In the past 16 years natural gas production has increased 200% and the price the consumer paid for gas has risen only 1/11th as much as the general cost of living.

Do Only A Few Big Companies Produce Gas?

No. The largest 37 companies produce less than half the nation's gas. No single company produces more than 5%. The small producers do more exploratory drilling than do all the big companies combined. And none of the producers has any monopoly, any exclusive franchise, or any protection.

What Is The Natural Gas and Oil Resources Committee?

It is made up of companies and individuals concerned with natural gas. It includes a great many large and small gas and oil producers. All believe there is no more reason for OPA-like price-fixing on gas than on steel, coal, autos, meat, or shoes, which could be next. All believe that free competition is better for all of us than a price-controlled economy, which has historically led to stagnation, scarcity and rationing.

What Can I Do?

You can reason out the issues, reach your own conclusions, and make those conclusions known to your friends and neighbors.

Under free competition without federal regulation—

- Natural gas became plentiful—output rose two hundred per cent in the past sixteen years.
- Natural gas stayed reasonable—and gas prices to the consumer rose only one-eleventh as much as living costs in the past sixteen years.
- Natural gas has helped create thousands of jobs in industry and now supplies one-fourth of the nation's energy resources.

NOW . . . . . cumbersome federal controls threaten all this progress.

FOR MORE FACTS WRITE FOR THIS BOOKLET NOW!

You have the right to know the facts about this new government regulation—a peacetime control of free, competitive producers. Send today for the booklet, "Natural Gas—A Key Resource in Jeopardy."

NATURAL GAS

NATURAL GAS AND OIL RESOURCES COMMITTEE

Room 5401, 350 Fifth Avenue, New York 1, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.

How Can We Save You Money?

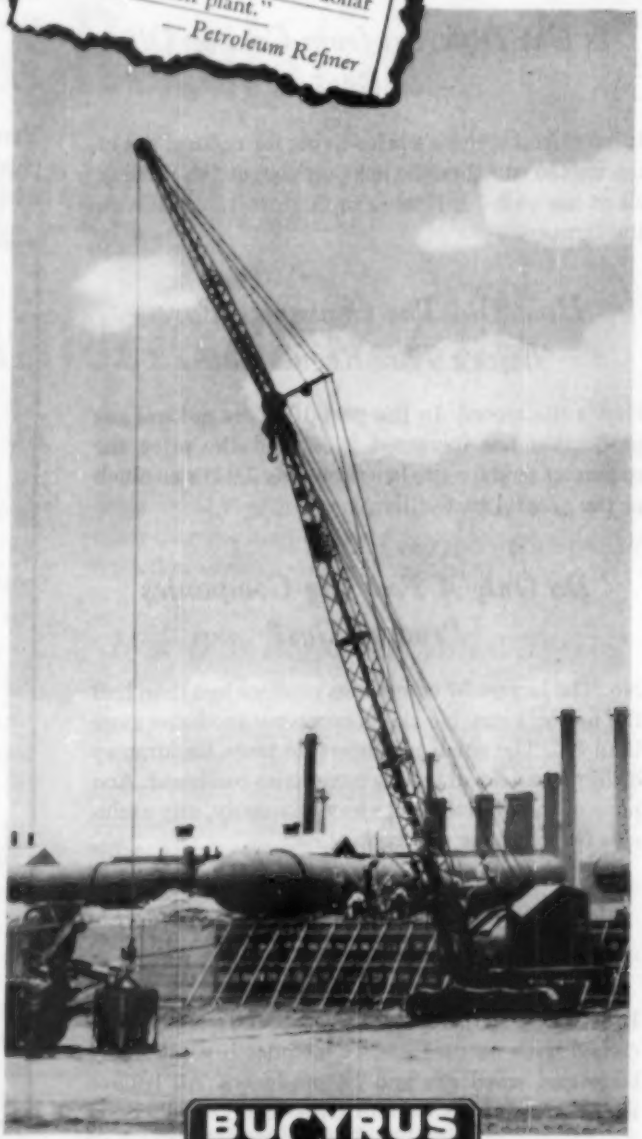
"Within the last two years, alert refinery managers, through the avenues of cost analysis techniques, have discovered something they never knew before—refinery maintenance is the biggest single dollar consumer in their plant."

— *Petroleum Refiner*

For quick, dependable handling of maintenance work at lowest possible cost you'll find you're ahead with a modern Bucyrus-Erie lifting crane, like the Model 22-B shown here. At this refinery a 22-B, equipped with 45-ft. boom and 15-ft. jib extension, is pouring concrete piers for a new addition — a fringe maintenance job, but one that shows the kind of jobs this versatile machine can do so effectively for you.

Lifting or loading jobs are easy for the speedy 22-B. Two variations of propel speed — low for ordinary moves, high for long distance travel — give it full mobility. A strong but lightweight boom, extendible to 70 feet by inserting sections, enables it to handle loads near the center of process units, eliminating the expense of installing built-in handling facilities. And boom control is accurate, reliable. The 22-B boom hoist is independent of all other functions —boom angle can be changed while the machine is swinging or propelling, while the load is being hoisted or lowered. One lever controls both raising and lowering of the boom.

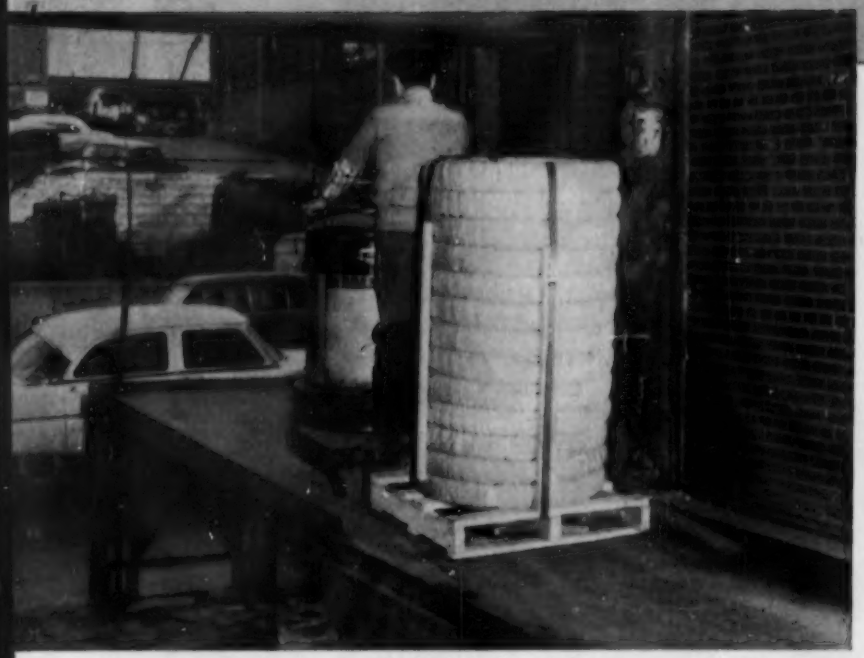
It will cost you nothing to learn the many additional reasons why Bucyrus-Erie cranes can help conserve your maintenance dollars. Ask our distributor in your area for full details on the complete Bucyrus-Erie line — crawler cranes from 3- to 60-ton capacity (nominal ratings); 15-ton and 25-ton capacity Transit Cranes. 43E54



BUCYRUS ERIE

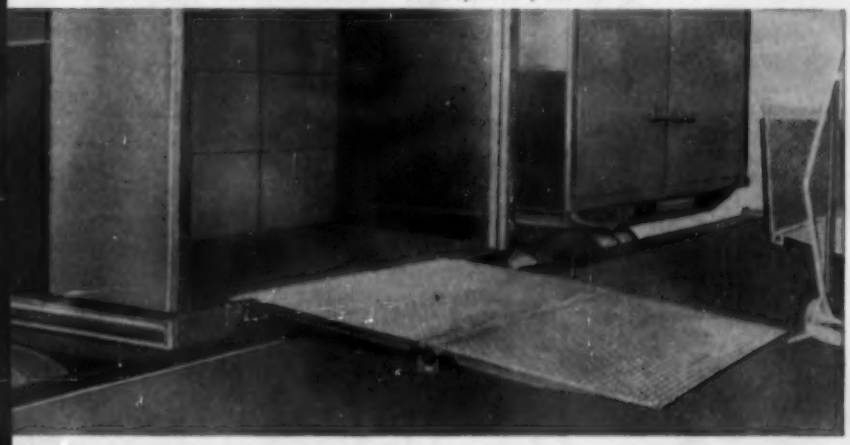
BUCYRUS-ERIE COMPANY South Milwaukee, Wisconsin

Superior Railway Products Corp. uses Multigrip to *safe-tread* their loading equipment



For safety's sake this "traveling" hydraulic loading platform—in use at The Kirby Storage and Transfer Co., Pittsburgh—is made of Multigrip. The platform travels out to where the truck can be easily loaded, and then travels back.

This portable, adjustable loading ramp is made of Multigrip too. The front leaf only need be raised as one truck leaves and another backs up to the platform.



TO BE SURE of maximum traction at all times for busy feet and wheels, Superior Railway Products Corp., of Pittsburgh, have safe-treaded the loading equipment they manufacture (see cuts) with USS Multigrip Floor Plate. Multigrip's sure-grip, never-fail risers prevent accidents from slips and skids (even when it is wet) wherever it is used.

You can install Multigrip with a minimum of trouble and expense for it is easy to cut and bend as necessary; it is available in large sections, reducing cutting waste; and its pattern is symmetrical, making it easy to match the sections. Multigrip lasts for years—it doesn't crack, chip, rot or splinter as other flooring materials do—requires practically no maintenance and is easy to keep clean.

Benefiting from the experience of others, it will pay you to make a careful check of all the potential danger spots in *your* plant or shop. Don't overlook: aisles around machinery, all ramps and stairs, runways and catwalks, warehouse floor and loading areas, and the entire plant floor area too. Multigrip protects your floors as well as your workers . . . all heavy traffic areas should be protected with heavy duty Multigrip for longer life. Can be used as a covering or structurally.

SEE The United States Steel Hour. It's a full hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL CORPORATION, PITTSBURGH
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, CHICAGO
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS multigrip FLOOR PLATE

Sold by leading distributors from coast to coast S-297

UNITED STATES STEEL

HOW TO EARN AN ENCORE IN THE PETROLEUM INDUSTRY

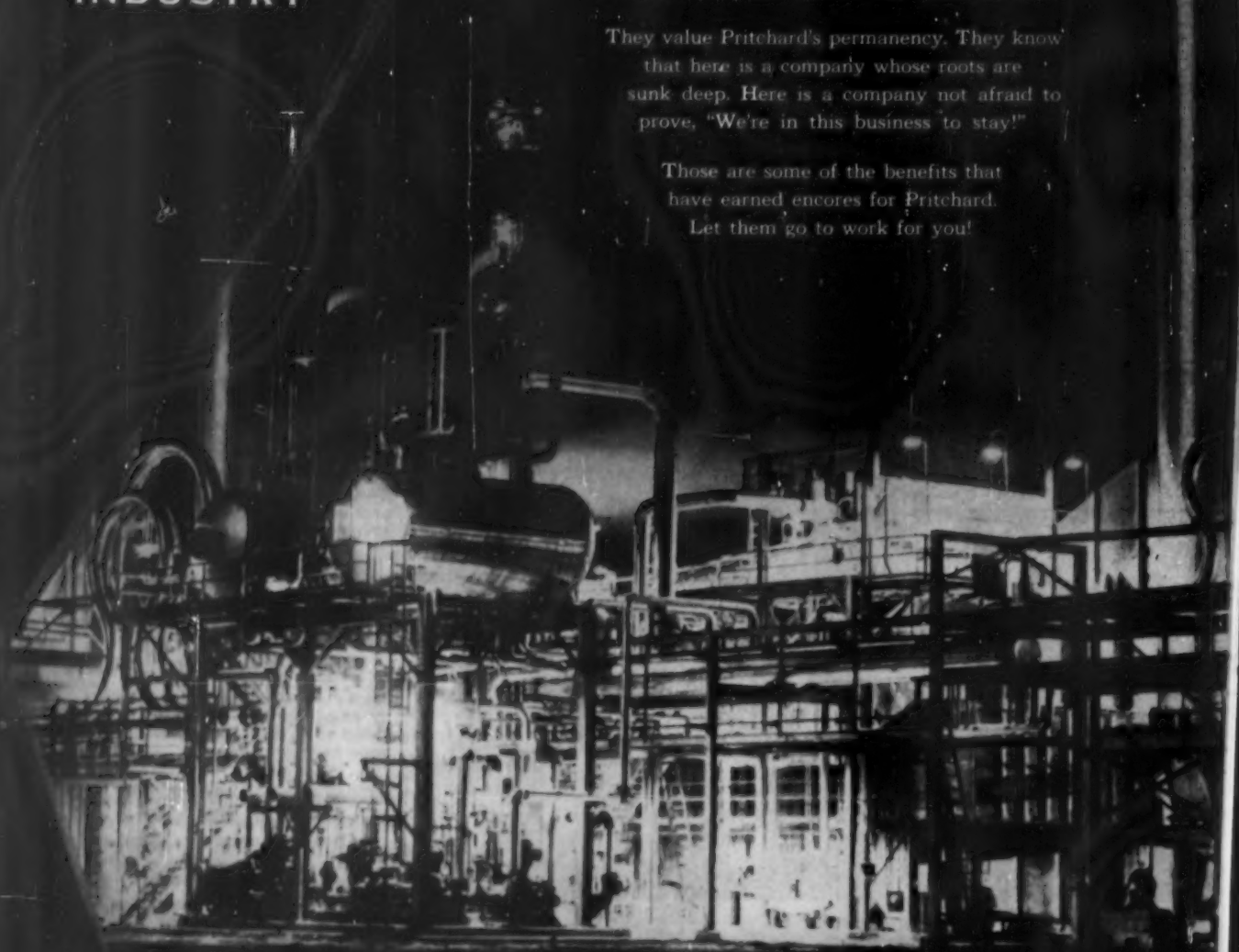
Get the job done right!

That's why Pritchard is proud of its many encores in the design, engineering and construction of refineries and off-site facilities. The many companies who chose Pritchard again after a successful initial experience are evidence of Pritchard's ability *to get the job done right* . . . and right on time.

These companies also appreciate Pritchard's single responsibility contract. They enjoy the extra cooperation Pritchard personnel offer their staffs, all the way down the line.

They value Pritchard's permanency. They know that here is a company whose roots are sunk deep. Here is a company not afraid to prove, "We're in this business to stay!"

Those are some of the benefits that have earned encores for Pritchard. Let them go to work for you!



Refinery off-site facilities designed, engineered and constructed by J. F. Pritchard & Co.

INDUSTRY'S PARTNER FOR PROGRESS

SERVING THE GAS, POWER, PETROLEUM AND CHEMICAL INDUSTRIES

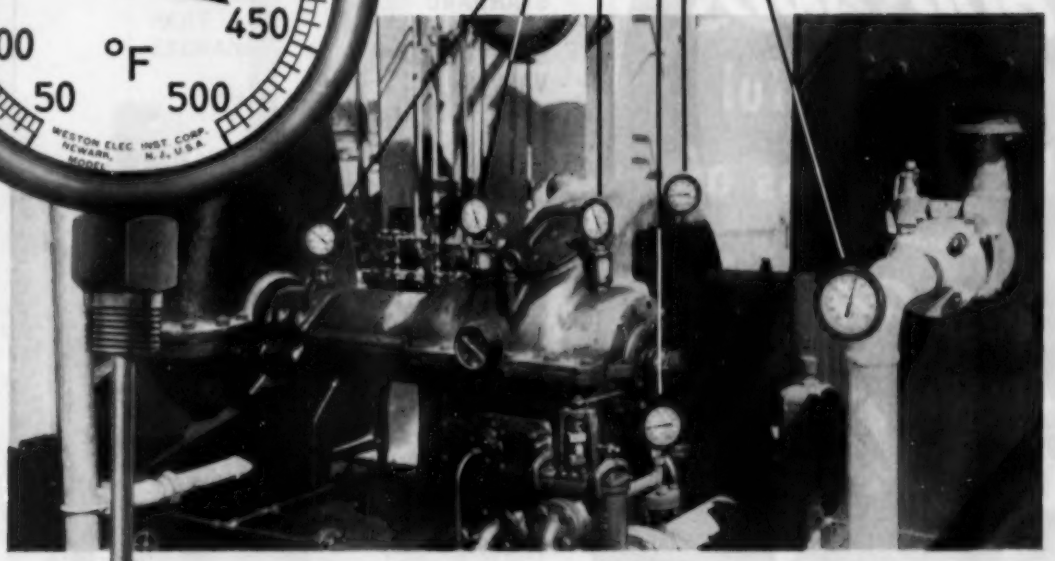
CHICAGO
HOUSTON
NEW YORK
PITTSBURGH
ST. LOUIS
TULSA

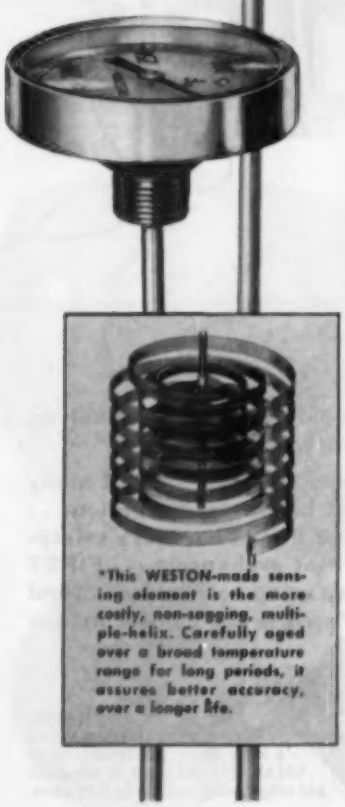
J.F. Pritchard & Co.

ENGINEERS & CONSTRUCTORS

Dept. 431 6625 Roanoke Parkway, Kansas City 17, Mo.

AT EVERY CHECKPOINT





*This WESTON-made sensing element is the more costly, non-sagging, multiple-helix. Carefully aged over a broad temperature range for long periods, it assures better accuracy, over a longer life.

WESTON *all-metal* THERMOMETERS

(with Multiple Helix)*

Here's another typical example of how large processing plants have solved temperature checking problems, and cut thermometer costs besides. With a WESTON dial-type thermometer at every checkpoint, temperatures are read at a glance . . . in far less time, and with far greater accuracy. Their sturdy all-metal construction resists breakage, gives them far longer life on operating equipment. And the exclusive WESTON multiple helix employed assures dependable accuracy during all this long life.

Available in a broad selection of types, sizes, ranges and stem lengths, WESTON thermometers are today standard on all types of mobile and stationary equipment and machines, large and small; as well as on piping, conduit, ducts, etc. Ask your distributor, or local WESTON representative for complete information, or write for descriptive bulletin . . . WESTON Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, New Jersey.

WESTON 5537 *Thermometers*

Stocked by leading Distributors

For more data on advertised products, use Readers' Service Cards, last page.

PROVEN by 8 years

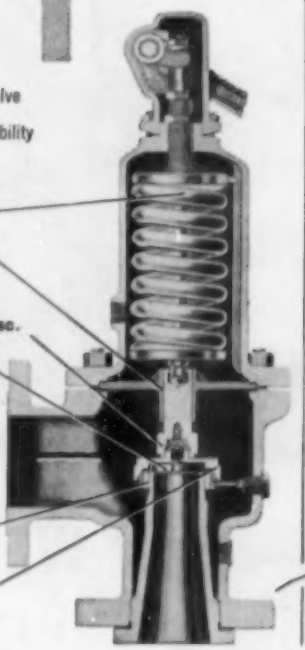
THOUSANDS of Successful Installations of Farris "4 in 1" Safety Relief Valves*

NOTICE: Farris Safety Relief Valves, the Internal Heat Exchanger, and Bellows construction are covered by U.S. Patents and Patents Pending. Copyrights, where applicable, are registered.

1 STANDARD FULL NOZZLE SAFETY RELIEF VALVES

Here is the ultimate in nozzle valve construction with complete standardization and interchangeability in every part:

- Round wire springs calibrated for rating.
- 2½ to 1 guiding ratio, close tolerances.
- Alignment spool for perfect alignment and bearing from stem to disc.
- Self-aligning, optically-flat replaceable disc of forged Stainless Steel.
- All bearings of hardened Stainless Steel.
- Expanded orifices increase capacity.
- Single blowdown ring does not affect capacity —simple adjustment.
- Flared disc-holder for ultimate operating efficiency.



BALANSEAL© SAFETY RELIEF VALVES

BalanSeal construction isolates all working parts. It consists of a neutral area bellows equalling the area of the seating surface, incorporating a mechanically-held seal for the lower part to greatly enhance replacement. BalanSeal can be simply installed any time. Because BalanSeal neutralizes effects of back pressures, resulting in a constant, safe relieving point on the upstream side, size of back pressure piping can be drastically reduced—for pipe savings up to 15 times the cost of the valve! Where accurate set points must be depended upon, BalanSeal stands alone.

For eight years Farris has been setting-the-pace-in-safety with "4-in-1" Safety Relief Valves, the "standard" for long service life, minimum maintenance and positive protection.

Farris' recognition as the pace-setter of the industry is no accident, but the result of many engineering "firsts" in improved valve design—FIRST with balanced bellows construction . . . FIRST to offer multiple nozzle sizes within one valve . . . FIRST with a line of bar stock safety-relief valves for pressures to 10,000 lbs. . . . FIRST to offer internal heat exchangers . . . FIRST to offer realistic pricing, giving the customer the benefit of manufacturing economies . . . and only Farris can point to proved-in-service performance . . . because Farris is the pioneer manufacturer of safety relief valves with bellows.

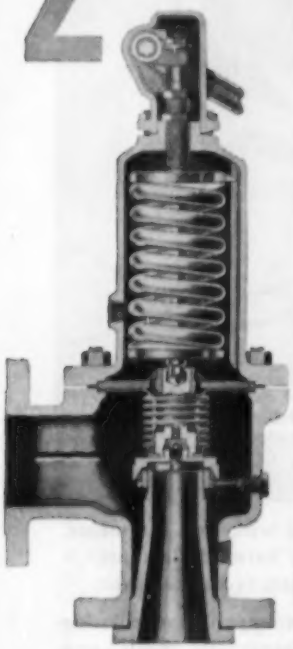
FOR ENGINEERS: Catalog 48Ra on the full line of Farris Safety Relief Valves; and Technical Manual 518—"Principles of Manifold Discharge Piping". Available on request.

"THE FOX AND THE HARE"

Send for this popular entertaining pamphlet presenting a story about the recognition of BALANSEAL valves. It is humorous and enlightening. Just ask for it by name.

# of ACTUAL SERVICE

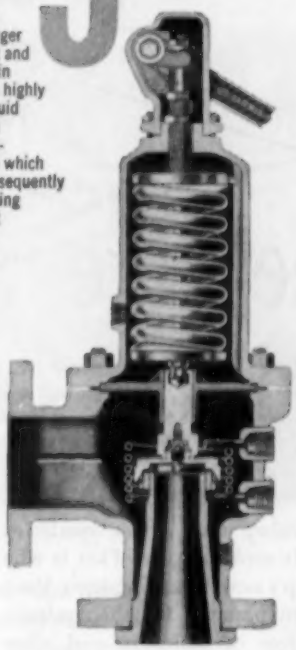
2



INTERNAL HEAT EXCHANGER

The exclusive Farris Internal Heat Exchanger eliminates inefficient and costly steam tracing in a valve body to keep highly viscous media in a fluid state. It consists of a stainless steel coil inserted in the body to which steam is fed and subsequently trapped out. For placing heat where it is most effective, increasing efficiency, lowering steam consumption, the Farris Internal Heat Exchanger is the only available product of its kind.

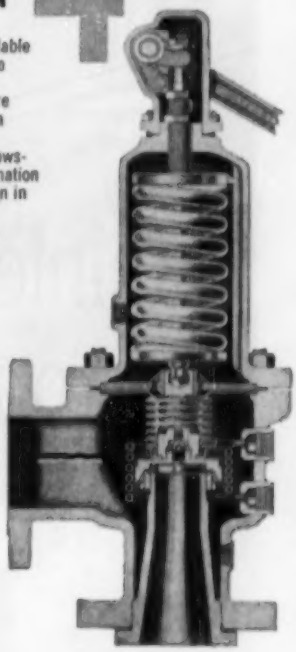
3



BELLOWS—HEAT EXCHANGER COMBINATION

For completely dependable valve operation in spite of sticky fluids (tars, asphalt, etc.) and where complete freedom from contamination is required, select the Bellows-Heat Exchanger combination . . . The ultimate design in safety relief valves for applications where material is highly viscous. All parts are Farris Standard construction.

4



*** CERTIFIED AND APPROVED by the National Board of Boiler and Pressure Vessel Inspectors, complying with ASME requirements. Tests made at university laboratories by independent observers. Certification data available on request.**

and Still the Lowest Prices in the industry!

Coming Soon!

An added line of ultimate capacity nozzle valves

Farris ENGINEERING CORPORATION

425 COMMERCIAL AVENUE, PALISADES PARK, NEW JERSEY

Affiliates: Farris Flexible Valve Corp. • Farris Stäcon Corp. • Farris HydroTorque Corp.
Farris HydroSeal Corp. • Farris Pickering Governor Co.

stainless steels are thoroughbred, too

The experienced exhibitor rents extra stalls... leaves them empty... to prevent contamination of his thoroughbred pets by canine neighbors.

To develop their best qualities demands *exclusive* care. That is why Sun Ship's new Alloy Products Shop has been planned for the *exclusive* fabrication of stainless and alloy steel products. When you have selected from the many available Alloys a stainless steel best suited for your service condition, you have done only half the job. You must also provide for the best possible fabrication if you are to have full protection—"A Thoroughbred Job."

Why entrust stainless steel to be fabricated in the same shop where carbon steel products are fabricated, and subject this precious metal to contamination with iron fragments, dust, or other harmful elements? A segregated shop is your answer.

Sun Ship now operates an all-alloy shop, one especially built and equipped for fabricating stainless and alloy products as they should be—segregated from carbon steel fabrication.

We emphasize the fabrication of medium and heavy stainless, alloy and aluminum products for industry.

Try Sun Ship for stainless fabrication as it should be done.

Our Sales Engineering Department will be pleased to assist you with any of your fabrication problems.

Sun Ship also makes all types of carbon steel pressure vessels.

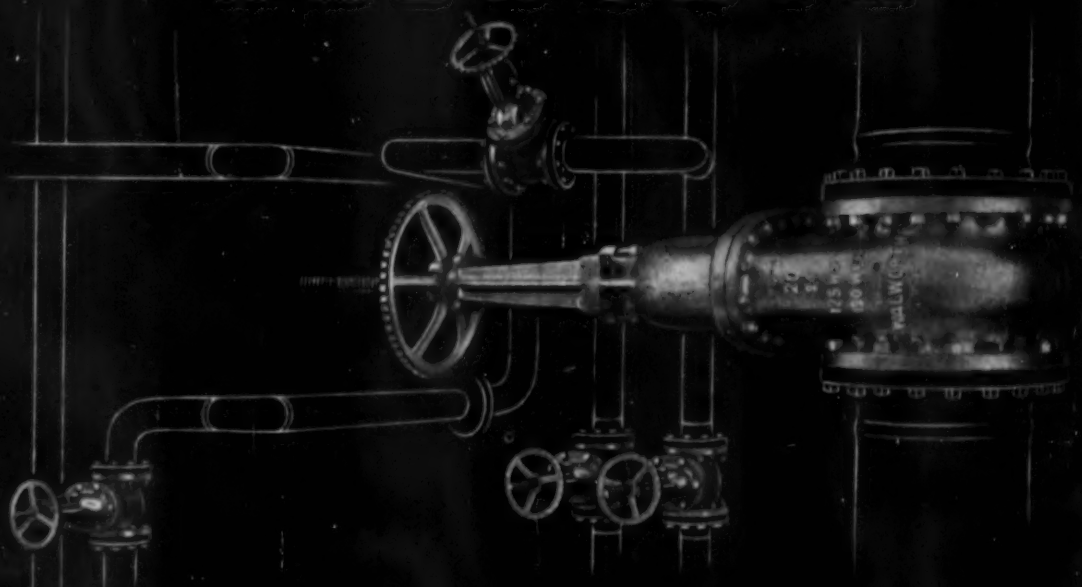
ALLOY PRODUCTS SHOP

OF Sun SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • CHESTER, PA. • 25 BROADWAY, NEW YORK CITY

For more data on advertised products, use Readers' Service Cards, last page.

WALWORTH



IRON BODY WEDGE GATE VALVES

Better because ...**The entire valve, from handwheel to seat rings, is ruggedly constructed to withstand rough and frequent usage. Body, bonnet, and yoke are sturdy castings with large radius fillets. Dimensions and drilling of end flanges are in agreement with American Cast Iron Flange Standards. Stiffening ribs connect end flanges with the body neck to maintain a rigid connection with piping.**

A wide range of Walworth Iron Body Wedge Gate Valves is available—through your Walworth Distributor—from which you can choose the right type to meet your most exacting conditions. Saddle-type valves as small as ¼-inch; low pressure valves for water and gas pipelines up to 36 inches.

Whenever you need valves and fittings, choose from complete lines—in a variety of metals—manufactured by Walworth. For more information, see your Walworth Distributor or write: Walworth Company, General Offices, 60 East 42nd Street, New York 17, N. Y.

Walworth No. 726F OS&Y (Outside Screw and Yoke) Iron Body Wedge Gate Valve. OS&Y valves are recommended for services where it is desirable that the line fluid does not come in contact with the stem threads. Note the swing-type gland-eye-bolts for easy repacking. Sizes 2 to 30 inches.

WALWORTH

Manufacturers since 1842

valves . . . pipe fittings . . . pipe wrenches

60 East 42nd Street, New York 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

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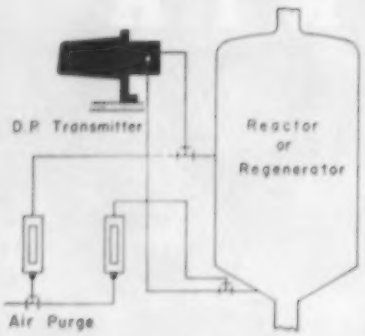
CATALYST LEVEL

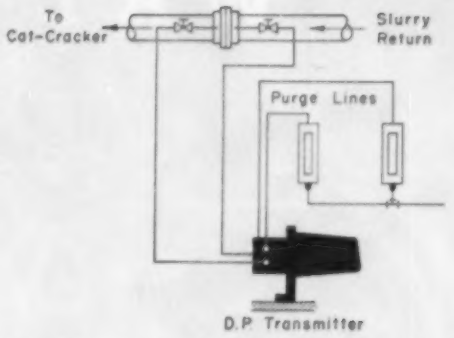


Problem: Sensitive Level Measurement of fluid catalyst in Reactor or Regenerator requiring a range of approximately 600 inches of water, and with a unit having parts common to other process measuring elements.

Solution: Use of a 333RD force-balance differential pressure transmitter with an available range adjustment of 80 to 800 inches of water.

Result: Accurate, Sensitive and Dependable level measurement with complete interchangeability of pneumatic transmitter parts.

AUTOMATIC PURGING OF SUSPENDED SOLIDS

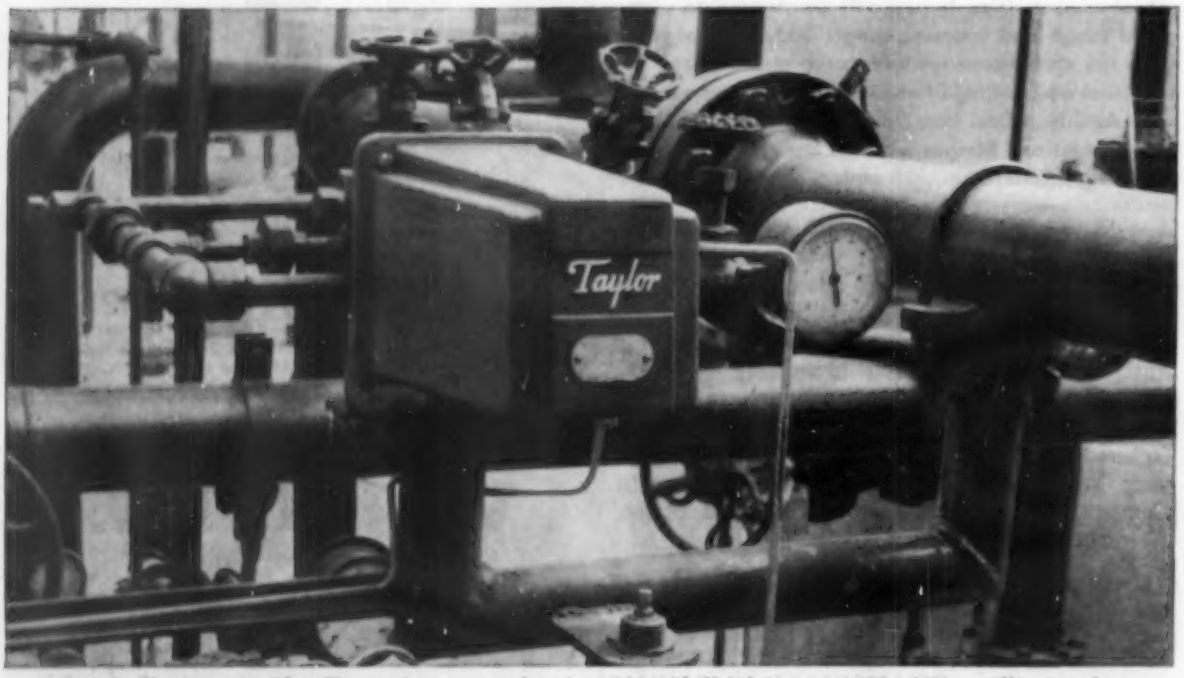


Problem: To obtain uninterrupted flow measurement and control in slurry lines where catalyst solids in suspension can settle out, plugging lead lines and meter, and causing measurement errors.

Solution: Dual body taps provide for purge connections which keep 333RD body, as well as lead lines, completely flushed.

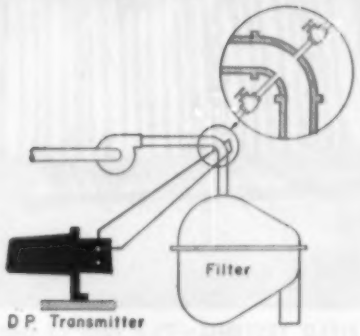
Result: Consistent, dependable high measurement accuracy. Flushing of transmitter body as well as lead lines cuts maintenance to a minimum, especially after shutdown.

A SIMPLE ANSWER TO



One of the TRANSAIRE Flow Transmitters on a reforming unit at Shell Oil Company's Wood River, Illinois, refinery.

SHORT RUNS—REVERSE FLOW—VARYING VISCOSITY

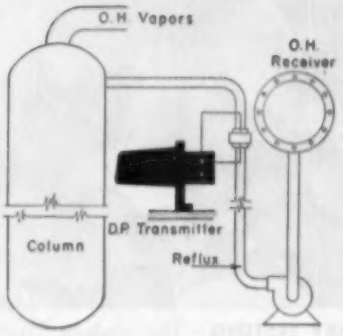


Problem: Dependable flow measurement installation where piping runs are too short for accurate orifice plate installation, the flow is reversed and/or flowing liquid has a varying viscosity.

Solution: The use of the 333RD Transmitter with Elbow Taps as primary elements. Since there is a tendency toward cavitation at the inside tap, the low volumetric displacement of the 333RD makes this type of installation practical.

Result: Accurate measurement and control under any one or more of these three difficult conditions.

WHEREVER A GOOD "WORK HORSE" IS REQUIRED



Problem: To improve flexibility, as well as reduce installation and maintenance costs of conventional flow instruments.

Solution: Standardizing on the 333RD Transmitter. 10-to-1 quick and easy range change; minimum volumetric displacement; may be installed for continuous draining and venting; light weight.

Result: Reduced maintenance cost due to time saved installing, changing of range, and eliminating periodic draining or venting.

DIFFICULT PROBLEMS!

The Taylor TRANSAIRE® Differential Pressure Transmitter (333RD) combines rugged simplicity with remarkable adaptability!

THREE of the applications illustrated above present difficult flow and level measurement problems: the fourth is an every-day installation. In each case the 333RD Transmitter handles the job accurately, dependably and economically.

This very versatile instrument is inexpensive and easy to install, and to maintain; changes in product or seasonal demand cause no problems, due to quick, simple range-change features; it follows flow changes quickly because of low volumetric displacement—has no seal pots.

Some of the features that make it so popular for refinery applications, are:

1. Good overrange protection, due to precisely designed and manufactured back-up plates and use of strong, flexible Teflon-coated glass fabric diaphragm.

2. Negligible temperature effect resulting from proven design principles and use of low-spring-rate materials.

3. Ease of range suppression by means of an easily accessible, easily adjustable spring.

If you need dependably accurate measurement of flow, liquid level or specific gravity, it will pay you to look into the 333RD. Call your Taylor Field Engineer, or write for **Bulletin 98097.** Taylor Instrument Companies, Rochester, N.Y., or Toronto, Canada.

Taylor Instruments
MEAN
ACCURACY FIRST
IN HOME AND INDUSTRY

For more data on advertised products, use Readers' Service Cards, last page.

LABORATORY TESTING—The modern Chase laboratories provide an excellent testing ground for heat exchanger tubes under conditions met in many varied industries.

FIELD TESTING—This rack of test specimens was in a heat exchanger. These field tests help Chase perfect the alloy best suited for *your* job.

How to be *SURE* about HEAT EXCHANGER TUBES

Take Chase Antimonial Admiralty or Cupro-Nickel Tubes, for instance. You *know* they'll give you years of service. They're manufactured under carefully controlled conditions. They're tested for every stress, strain and attack. They're inspected again and again. When a Chase heat exchanger tube goes into service we're *sure* it will stand up. You can be sure, too.

CHASE WAREHOUSE STOCKS:
Houston,* Los Angeles, New Orleans, Tulsa**

CARE IN MANUFACTURE—During every step of the way from casting to packing, Chase heat exchanger tubes are carefully supervised and continually tested.

YEARS OF ACTUAL USE—Chase condenser tubes and heat exchanger tubes save industry thousands of dollars annually . . . because they last longer.

Chase

BRASS & COPPER CO.

WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

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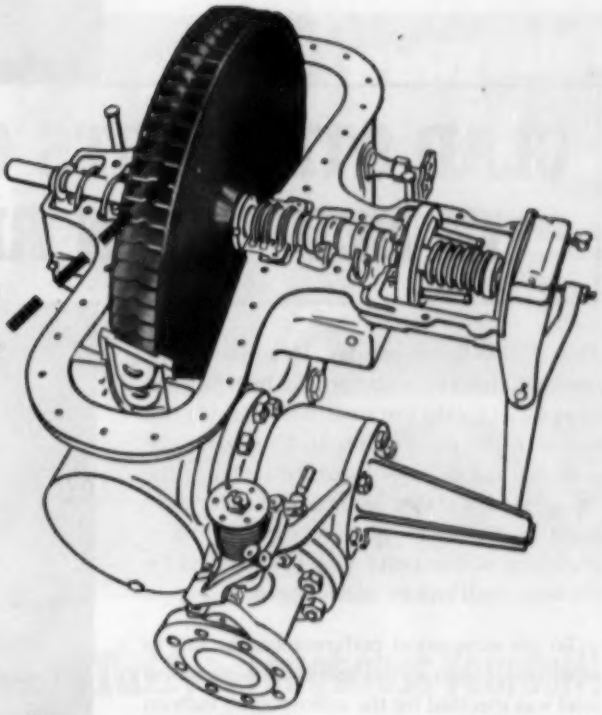
Charlotte†	Denver	Kansas City, Mo.	New Orleans	Rochester†	(sales office only)

TERRY SOLID WHEEL



..."trade mark" of a trouble-free turbine

This is the rotor of a Terry solid-wheel turbine. There are a number of reasons why it has become a symbol for reliable, trouble-free operation.

First, because the wheel is a single forging, in which a series of semi-circular buckets is milled, there are no separate parts to become loose or work out.

Second, because the power-producing action of the steam takes place on the curved surfaces at the back of the buckets, blade wear is of little consequence. Wear does not materially affect horsepower or efficiency.

Third, because the steam enters the buckets in a direction at right angles to the shaft, there is no need for close axial blade clearances. The blades cannot foul. There is a one inch clearance on either side of the wheel. In addition, the blades are double rim protected.

These are only a few of the reasons why the Terry solid wheel has become a "Trade Mark" for trouble-free turbine performance. For complete details, send for a copy of bulletin S-116. No cost or obligation.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TERRY

TT-1197

For more data on advertised products, use Readers' Service Cards, last page.

CLAD STEEL CUTS CORROSION IN NEW TWIN REACTORS

This 25,000-barrel-per-day Houdriflow cat-cracker features twin reactor-kilns built into one large vessel for the first time. But designing this unit presented many problems. The reactor, for instance, had to resist corrosive action of the crude fraction at temperatures in the neighborhood of 950°F. To get *economical* corrosion resistance, stainless-clad steel was specified for the cone, shell and an internal head.

To get economical performance like this in other major units of this refinery, stainless-clad steel was specified for the atmospheric, vacuum and synthetic crude towers and for the flash fractionator to minimize corrosion, downtime and equipment failure. The light layer of cladding, inseparably bonded to the carbon or low-alloy backing steel, gives the performance of expensive solid high-alloy plate at much lower cost. Strength and rigidity are supplied by the backing plate.

Now this refinery is ready to meet increasingly competitive conditions as the result of an expansion program that raised operating efficiency and tripled throughput. While still in the planning stages, the refiner's engineers called on the equipment builder to help translate their ideas into the specialized equipment needed. His particular knowledge of fabricating techniques utilizing clad steel helped put this refinery ahead in output and profit. You, too, will find that it pays to consult your fabricator early in your planning for equipment that is lower in cost, longer lived and requires less maintenance.

Clad steel in this Houdriflow cat-cracker provides economical corrosion resistance at high temperatures

Ask one of your fabricators to show you the new Lukens clad steel movie, "Equip for New Profits." Here—in full color and sound—are factual accounts of how clad steel equipment brings new economies. The story can suggest new ideas to everyone concerned with production efficiency. Or contact Manager, Marketing Service, Lukens Steel Company, 751 Lukens Building, Coatesville, Pa.

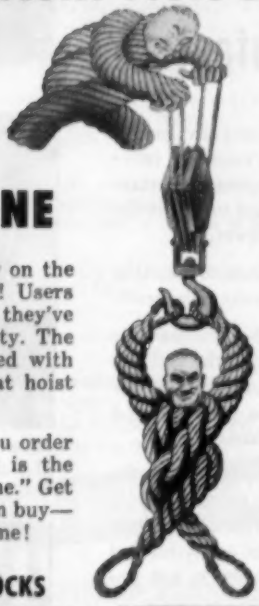
LUKENS CLAD STEELS

STAINLESS-CLAD · NICKEL-CLAD · INCONEL-CLAD · MONEL-CLAD

PRODUCER OF THE WIDEST RANGE OF TYPES AND SIZES OF CLAD STEELS AVAILABLE ANYWHERE

NOW!
TORTURE-TEST a Tuffy SLING FREE!

Run Your Toughest Tests! Prove Tuffy's Toughness Yourself!



Tuffy HOIST LINE

Equals Tuffy Slings in ability to stay on the job longer . . . reduce operating costs! Users report Tuffy Hoist Line is the best they've ever seen for strength and wearability. The reason? Tuffy is specially constructed with the extra flexibility and stamina that hoist line work *demands*.

No Confusing Specifications! When you order Tuffy, all you tell your distributor is the length, diameter and "Tuffy Hoist Line." Get all the hoisting service your money can buy—reeve *your* crane with Tuffy Hoist Line!

YOUR Tuffy DISTRIBUTOR STOCKS THE REPLACEMENT ROPES YOU NEED!

Just Give Him An Idea of your future requirements and he will stock up from his nearby Union Wire mill depot. That way, when you need rope in a hurry, he's ready to rush it to you immediately! Talk over your replacement schedule with your Tuffy distributor *today*.

union Wire Rope **corp.**

Specialists in High Carbon Wire, Wire Rope and Braided Wire Fabric

Kink It, Loop It, Jerk It! Tie knots in your free Tuffy Sling or use it to hoist weights up to *twice* the rated working load! Do your worst to the Tuffy Sling we give you and you'll see why we say Tuffy is the toughest sling you can buy!

Exclusive, Patented Construction of machine braided wire fabric makes Tuffy Slings extra flexible to resist kinking. And if you *can* kink it, you'll be able to straighten your free Tuffy Sling—or any Tuffy Sling—easily with *no material damage*.

Find Out How Tuffy gives you unbeatable service under stresses and strains of all kinds. Send for your free Tuffy Sling and convince yourself that Tuffy is the toughest in the business!

TEAR OFF AND MAIL COUPON NOW

Union Wire Rope Corporation
2284 Manchester Ave., Kansas City 26, Mo.

At no cost or obligation to me, please rush the material I have checked:

- ☐ FREE 3-Ft. Tuffy Sling!
- ☐ FREE Sling Handbook and Rigger's Manual, Featuring 12 Tuffy Factory-Fitted Types!
- ☐ Name and Address of Tuffy Distributor Nearest Me!

FIRM NAME_____

BY_____ TITLE_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

At the Atlantic Refining Company's "Ultrawet" plant in Philadelphia, excess benzene is distilled off the alkylate and condensed in these Monel condensers. Monel is also used for neutralization tank, settler, soap evaporators, solvent extraction equipment, and steam coils in "Ultrawet" storage tanks and in tanks for storing 50% caustic soda.

How Monel protects against corrosion in Synthetic Detergent Manufacture

It's no wonder that The Atlantic Refining Company, one of the largest detergent manufacturers in the country, relies heavily on corrosion-resisting Monel to protect important process equipment items against corrosion and to insure the high purity of its synthetic detergent "Ultrawet."

For there are plenty of places where corrosion can take hold in the manufacture of alkyl aryl sulfonate detergents.

Among the corrosives which occur in the process are: sulfuric acid, sulfonic acids, dilute hydrochloric and hot caustic soda. In addition there is the problem of contamination: even slight traces of metallic corrosion products in a detergent may cause unwelcome odors and instability.

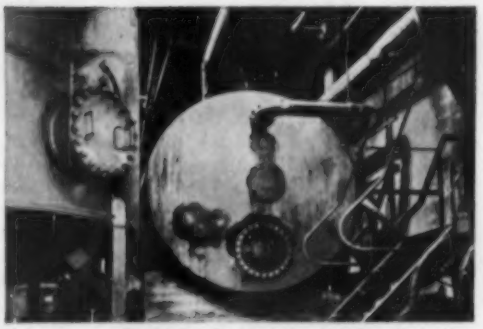
Service in many fields has proved that Monel is often the most economical material where a strong, tough alloy is needed to handle acids, alkalies and salts with a minimum of corrosion or contamination. Monel is an easily-formed structural material whose corrosion resistance is not impaired by welding.

If you would like to know whether Monel or one of the other Inco Nickel Alloys can help solve your corrosion problem, write to Inco's Corrosion Engineering Section. Our Technical Bulletin T-5 "Engineering Properties of Monel and 'R' Monel" is yours for the asking.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N. Y.

INCO Nickel Alloys

MONEL® • "R"® MONEL • "K"® MONEL • "KR"® MONEL • "S"® MONEL • INCONEL® • INCONEL "X"® • INCONEL "W"® • INCOLOY® NIMONIC® Alloys • NICKEL • LOW CARBON NICKEL • DURANICKEL®



After neutralization, the product is run into this Monel settler.

Soap solutions are evaporated to a concentrated slurry in Monel evaporators.

11 ALL-IMPORTANT FACTORS WHICH DETERMINE THE VALUE AND EFFICIENCY OF PROCESSING FURNACES

✔**UNIFORM HEAT DISTRIBUTION**
MAXIMUM FUEL EFFICIENCY
PLENUM CHAMBERS FOR HAZARDOUS AREAS
SIMPLICITY OF DESIGN AND CONSTRUCTION
EXCESS DRAFT FOR HIGH OVERLOAD
EXPLOSION RESISTANT
MINIMUM GROUND SPACE
SHORT LENGTH OF LIQUID TRAVEL
ZERO AIR LEAKAGE
LOW PRESSURE DROP
LOW MAINTENANCE

✔**UNIFORM HEAT DISTRIBUTION** the most desirable heater characteristic is created in an Iso-Flow furnace by:

1. Individual burners are so spaced in relationship to the heating elements that they create a symmetrical flame pattern with relation to the tubes;

2. The metal cone at the top of the combustion chamber re-radiates to the tubes, also diverts combustion gases progressively closer to the tubes to give a uniform heat intensity at the upper portion of the combustion chamber;

3. The combustion gases, at the top of the heater, are diverted towards the walls where they recirculate from the top of the heater downward, behind and between the tubes, increasing the heat input to the rear of the heating elements by convection;

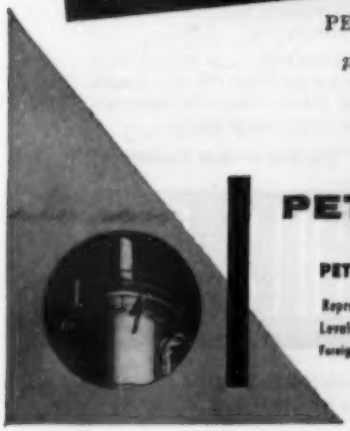
4. The recirculated gases reduce the heat intensity at the bottom of the furnace so that the heat input is the same, top and bottom.

These factors provide the completely uniform heat distribution required in heaters for the most efficient process operation.

In every case where these 11 all-important design characteristics were employed to compare one type of furnace design with another, PETROCHEM-ISOFLOW FURNACES *were proved most efficient by any comparison.*

Prove PETROCHEM-ISOFLOW FURNACES Most Efficient by Any Comparison

More than 1200 PETROCHEM-ISOFLOW FURNACES *are in operation throughout the world in the petroleum, chemical and allied industries . . . for all processes and for any duty, pressure, temperature and efficiency . . . and all Petrochem-Isoflow Furnaces are pre-eminently satisfactory.*



PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE ... CAPACITY ... DUTY

PETRO-CHEM DEVELOPMENT CO., INC. • 122 East 42nd St., New York 17, N. Y.

Representatives: Bethlehem Supply, Tulsa and Houston • Flagg, Brockett & Durgin, Boston • D. D. Foster, Pittsburgh • Faville-Levally, Chicago • Lester Oberholtz, Los Angeles • Gordon B. Hardin, Louisville • Turbux, Philadelphia (Norberth, Pa.)
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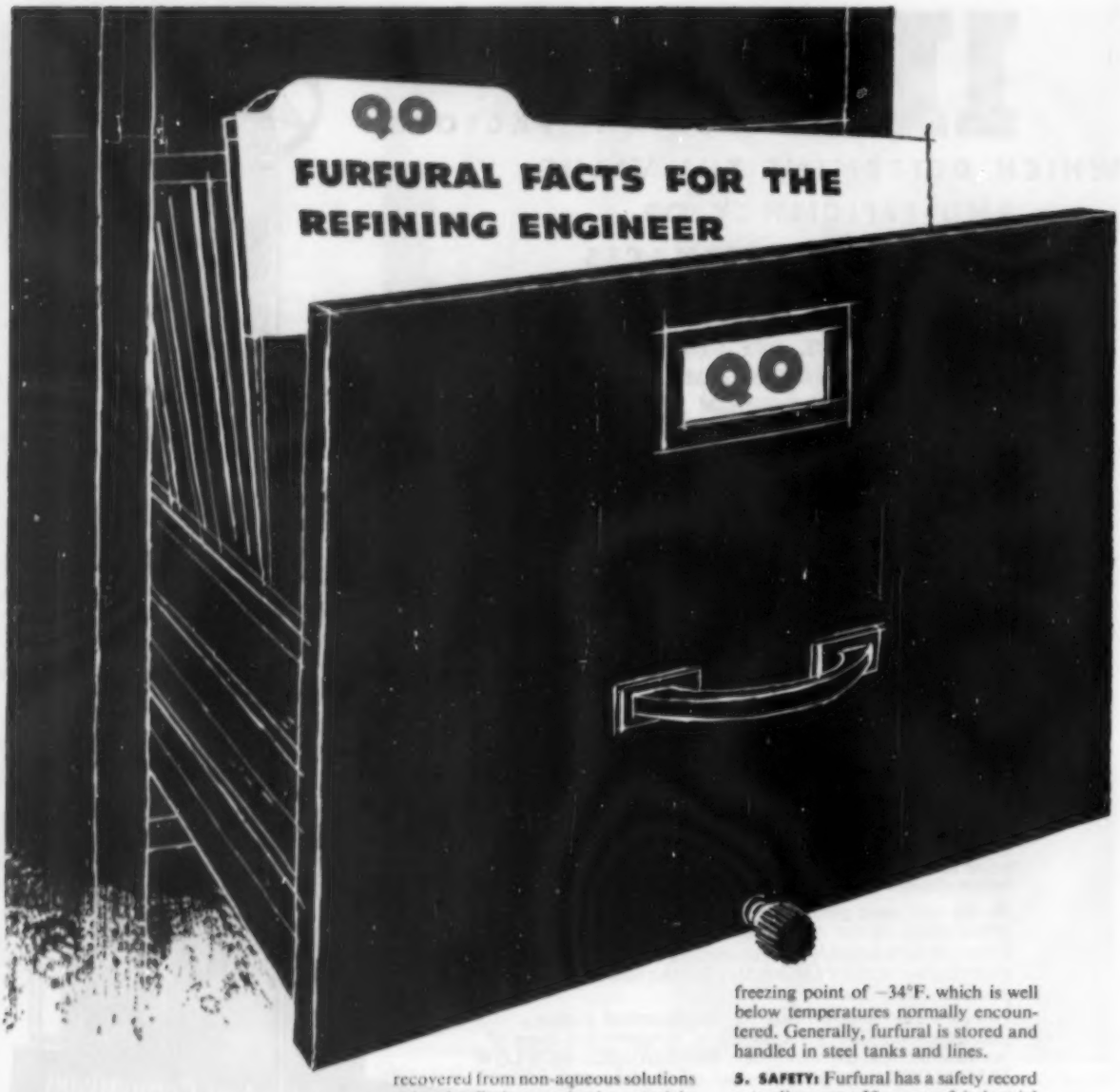

What Makes Furfural So Good As a Selective Solvent?

1. SELECTIVITY: Furfural is highly selective; it is a polar molecule and gives a sharp separation. Its high specific gravity permits rapid phase separation.

2. EASE OF RECOVERY: Furfural may be readily recovered from aqueous solution by steam stripping; it may be recovered from non-aqueous solutions either by flash vaporization, straight distillation, steam stripping, or extraction with water.

3. STABILITY: Under the conditions encountered in refining, furfural has a high degree of stability, as shown by the low solvent losses in operating plants around the world.

4. STORAGE: It is not necessary to use special handling precautions for cold weather operation since furfural has a freezing point of −34°F. which is well below temperatures normally encountered. Generally, furfural is stored and handled in steel tanks and lines.

5. SAFETY: Furfural has a safety record extending over 30 years of industrial use. It has a high flash point (150-160°F.), and a vapor pressure of 8 mm. Hg at 39.9°C.

6. COST: Furfural is low in price, and with high recovery, overall solvent costs are attractively low.

7. AVAILABILITY: Large quantities of furfural are produced the year around at three plants from raw materials which are replaceable yearly.

If you would like to know more about the properties of furfural, write for our Bulletin 203 "Physical Data on Furfural."

The Quaker Oats Company **CHEMICALS DEPT.**

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Room 5400, 120 Wall St., New York 5, N. Y.
Room 4400, P. O. Box 4376, Portland 8, Oregon
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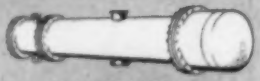
SPECIFICALLY DESIGNED...

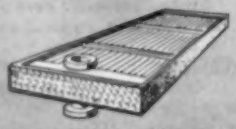
FOR THE REQUIREMENTS OF THE JOB!

HEAT EXCHANGERS

REBOILERS



CONDENSERS



ATMOSPHERIC SECTIONS
(Horizontal and Vertical)

STEAM GENERATORS

JACKET WATER COOLERS

EFCO HEAT TRANSFER EQUIPMENT

● EFCO engineers can supply you with any type of heat transfer equipment to meet your specifications. Reboilers, condensers, atmospheric sections, jacket water coolers, steam generators and heat exchangers, made by EFCO specialists, are sturdily constructed to give long trouble-free service. Ask an EFCO engineer. He will be glad to help you with your heat transfer problems.

ENGINEERS & FABRICATORS, INC.
P. O. Box 7395 Houston 8, Texas

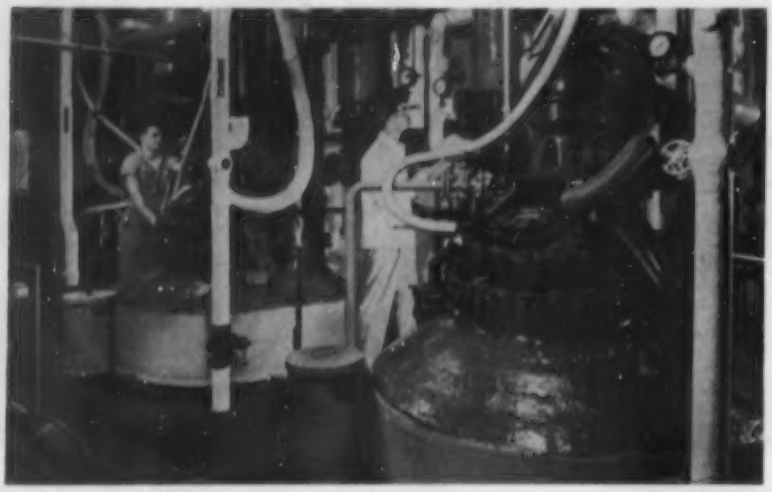
EFCO HEAT TRANSFER EQUIPMENT

For more data on advertised products, use Readers' Service Cards, last page.

Corrosioneering News

Quick facts about the services and equipment Pfaudler offers to help you reduce corrosion and processing cost.

Published by The Pfaudler Co., Rochester, N.Y.



How DPi, Leading Vitamin E Producer Maintains Absolute Product Purity

Concentrating and purifying Vitamin E from natural vegetable oils is a delicate job. It's the "house specialty" of Distillation Products Industries, a division of Eastman Kodak Company.

By molecular distillation, DPi produces tocopherols in a number of forms. In every phase of their process—particularly the final step—extreme care must be taken to protect these products from contamination.

Critical Stage

The final stage in DPi's preparation of Vitamin E requires the protection of Pfaudler glassed steel reaction kettles. Fortified with an acid-alkali resistant inner surface, these reactors resist all forms of chemical attack, protecting the product from contamination.

Use of Pfaudler glassed steel equipment typifies the care that has made DPi a leader in the research and production of Vitamin E, as well as Vitamin A and distilled monoglycerides.

You too can profit by using Pfaudler glassed steel reactors. They are available in a complete range of capacities, from laboratory to full-scale production. When you make use of the custom features Pfaudler has incorporated in their standard design, you are able to get delivery on these reactors within two weeks.

How to Cool Off a Heat Exchanger Problem

With new processes on the horizon every day, Pfaudler engineers are receiving more and more requests for special features on heat exchangers.

To save you money on these designs, they have found that Pfaudler "flexible standard" stainless steel heat exchangers can be used as the base unit in a high percentage of cases.

For example, nozzles of any size—either flanged or threaded—can be installed in any position. And new production line methods make possible rapid deliveries—as few as 7 days!

To solve your problem, Pfaudler sales engineers can select from a complete line of heat exchangers—fixed tube sheet, single or multipass, tube and/or shell side stainless steel units. Shell diameters range from 4" to 24" in four basic types of construction: fixed tube sheet . . . outside packed floating head design . . . internal floating head . . . U-tube bundle. Most have removable tube bundles.

To take the heat off that heat transfer problem, discuss it with your Pfaudler representative. He has plenty of equipment to choose from.

Tall Story Lies Behind This Canadian Column

Two-thirds of this giant column was fabricated from stainless steel. The rest is carbon steel.

Seventy-seven feet high, the column projects into the sky above Canadian Chemical Company's plant at Edmonton, Alberta. It is a good example of the type of design and fabricating attention your problem will get when you turn it over to Pfaudler engineers.

In this case, a column was needed for a big, and very specific type of job. Seventy-seven feet high by 54 inches in diameter, it required custom fabrication.

Giant column has 40 sieve trays, is made of two types of steel.

Ordinarily, Pfaudler engineers are able to use economical standard units to solve problems of distillation, fractionation, stripping, bleaching and absorption. This saves you money, gives you the advantage of interchangeable components and uniformity of equipment designs.

To give you long-life equipment, Pfaudler offers a complete range of corrosion-resistant materials. This includes stainless steel, Hastelloy, monel, nickel, inconel, aluminum, glassed steel, and others.

Cut your equipment costs, and get the advantages of unbiased selection of construction materials, with Pfaudler glassed steel and alloy columns.

PSC
BIG NAME IN
BUBBLE CAPS
300 STANDARD STYLES OF
BUBBLE CAPS & RISERS FURNISHED
without die cost
SEND FOR CATALOG 54
Contains complete engineering data on each of what, we believe, is the largest available choice of alloy bubble caps. Also drawings for use in determining methods of tray assembly. PSC caps are fabricated in any metal to meet your specific requirements.
THE
PRESSED STEEL
COMPANY
WILKES-BARRE, PENNA.
Offices in Key Cities

For more data on advertised products, use Readers' Service Cards, last page.

HARSHAW'S

Continuous Research Develops

stronger *tableted* catalysts

THE HARSHAW CHEMICAL COMPANY

Cleveland 6, Ohio

Chicago • Cincinnati • Cleveland • Detroit • Houston
Los Angeles • New York • Philadelphia • Pittsburgh

Taken at 1/20,000th of a second, the pictures show a Harshaw catalyst tablet being tested for strength—one step in our research program designed to produce more efficient tableted catalysts having the highest useful strength. Our goal, of course, is to make the catalyst you want and need. First you specify, and then we produce.

Tougher, more efficient catalysts mean fewer reactor shutdowns, and, naturally, more economic operation for you. Harshaw Catalysts mean fewer reactor shutdowns.

If your mind's on catalysts please contact us today by phone or letter.

HARSHAW CATALYSTS
available in these forms:

Tablets	Powders
Extrusions	Spheres
Granules	Rings
Flakes	

Keep Heat Transfer Surfaces CLEAN...

SPECIFY

Vogt

SCRAPED SURFACE *Exchangers*

IF you are all "gummed up" with a tough heat transfer problem, Vogt Scraped Surface Exchangers will provide the answer. They have patented scraper elements which prevent fouling of the heat transfer surfaces and insure the highest rate of heat exchange between the product and the cooling or heating medium. The scrapers also continuously agitate the fluid and assist removal of solids from the unit.

DOUBLE PIPE EQUIPMENT is available in two types; EXCHANGERS, for cooling with water, brine, and cold filtrate, and for heating with steam or hot liquids; and CHILLERS, for use with volatile refrigerants such as ammonia, propane, and Freon. Both types have 8" jacket pipes and 6" inner pipes with scrapers.

SHELL AND PIPE TYPE UNITS are designed for use with volatile refrigerants and for heating fluids with steam or similar heating mediums. They consist of large welded shells each containing seven 6" scraped pipe sections.

Vogt Scraped Surface Exchangers serve profitably as oil chillers, crystallizers, and heaters in many processes in the petroleum and chemical industries. Their application to your heat transfer problems will receive the prompt attention of our Engineering staff.

Write for Bulletin PE-1

*DOUBLE PIPE UNIT. Drive end close-up of 12 section unit under test in our shop.

*SHELL and PIPE UNITS. Two of five units installed in a leading petroleum refinery.

*Patented

HENRY VOGT MACHINE CO.

LOUISVILLE 10, KENTUCKY

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NEW YORK • PHILADELPHIA • CLEVELAND • CHICAGO

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NEW! ASHCROFT 2½" GAUGE

HAS TYPE 316 STAINLESS STEEL SYSTEM TO WITHSTAND CORROSIVE CONDITIONS

High resistance to corrosion and sustained high accuracy are combined in this new heavy-duty Ashcroft Gauge. The 2½" dial size makes this compact instrument ideal for small tanks and processing equipment where large pressure gauges would be impractical. Bourdon tube (welded at socket and tip) . . . square shank and ¼" male N.P.T. bottom connection . . . geared movement—the entire gauge system is Type 316 stainless steel.

Made in standard graduations from 30 psi through 1,000 psi, this new Ashcroft Pressure Gauge has a black dial with easy-to-read white figures. The drawn steel case and threaded ring are finished in black. Pointer is precision needle type. Every part is designed, tested and manufactured to meet rigid service conditions.

YOUR INDUSTRIAL SUPPLY DISTRIBUTOR now has this new Ashcroft Gauge in stock. Let him know your requirements. You can depend on him for experienced counsel and prompt delivery.

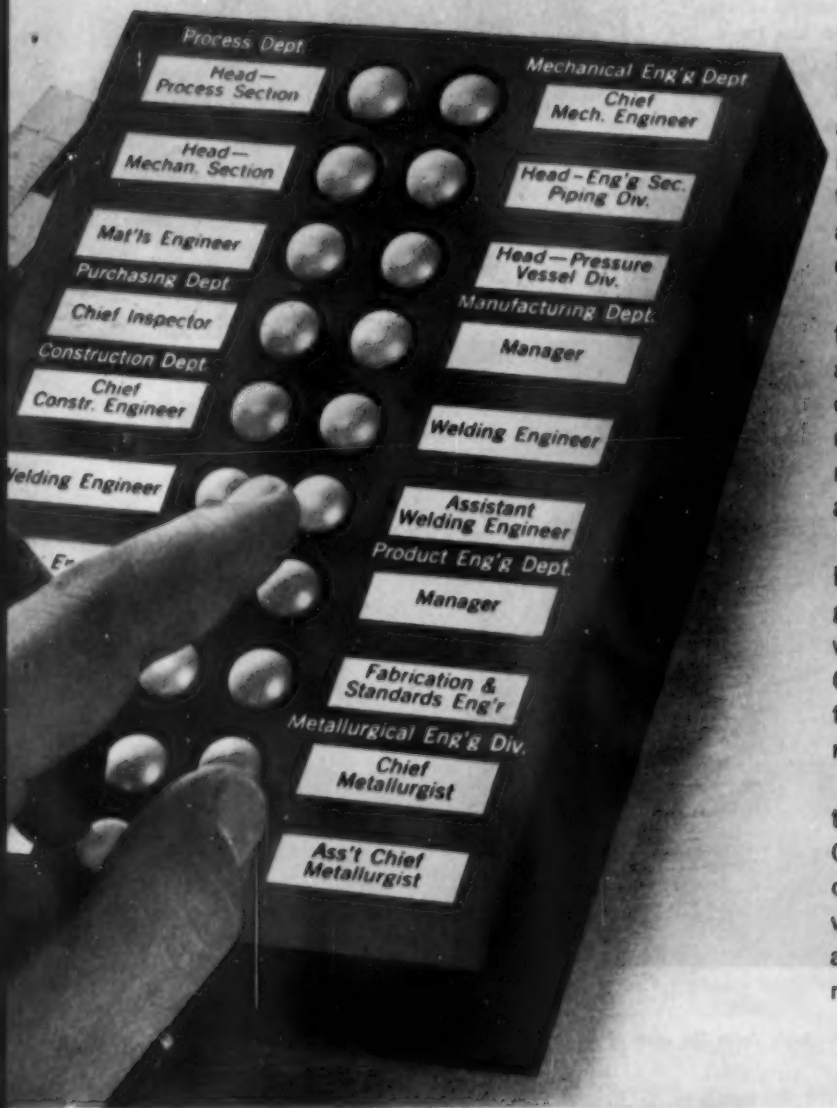
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

ASHCROFT GAUGES

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Oklahoma.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

High Pressure Answer Men

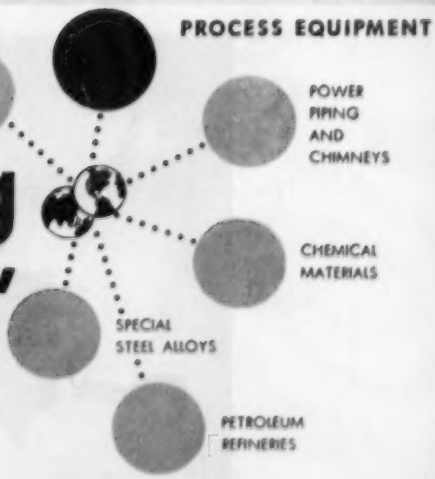


Increasingly high pressures and temperatures used in processes today demand the most advanced engineering and metallurgical treatment of the piping and equipment to handle them. The M. W. Kellogg Company has earned a long-standing reputation in this specialized engineering area.

Largely responsible for M. W. Kellogg's position is the company's "Committee on Materials and Fabrication" which meets regularly to discuss developments of pure and applied research as they concern service experience, metallurgical progress, welding techniques, and improved methods of fabrication.

Composed of principal engineers from M. W. Kellogg's process engineering, mechanical engineering, and construction departments, as well as the Fabricated Products Division, this Committee benefits all of the company's activities and the facilities they offer in their respective fields.

The Committee on Materials and Fabrication is one reason why The M. W. Kellogg Company is recognized as the leader in the design and fabrication of piping, pressure vessels, heat exchangers, waste heat boilers, and process equipment requiring transient and maintained pressures and temperatures.



M.W. Kellogg

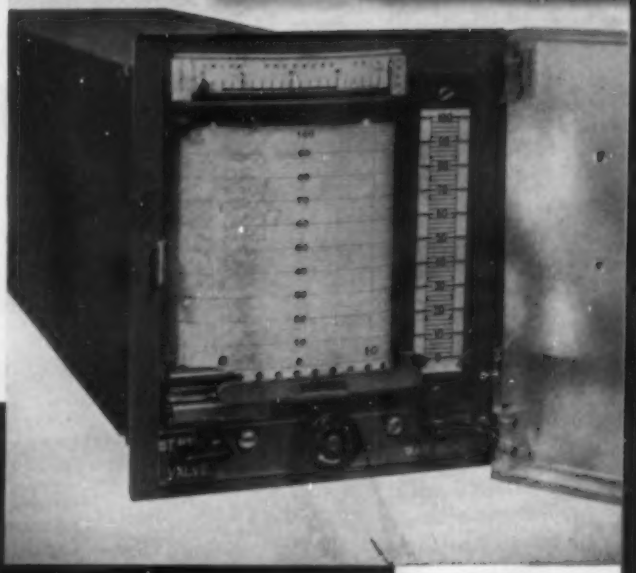
ENGINEERING FOR TOMORROW

THE M. W. KELLOGG COMPANY, NEW YORK 7, N. Y.

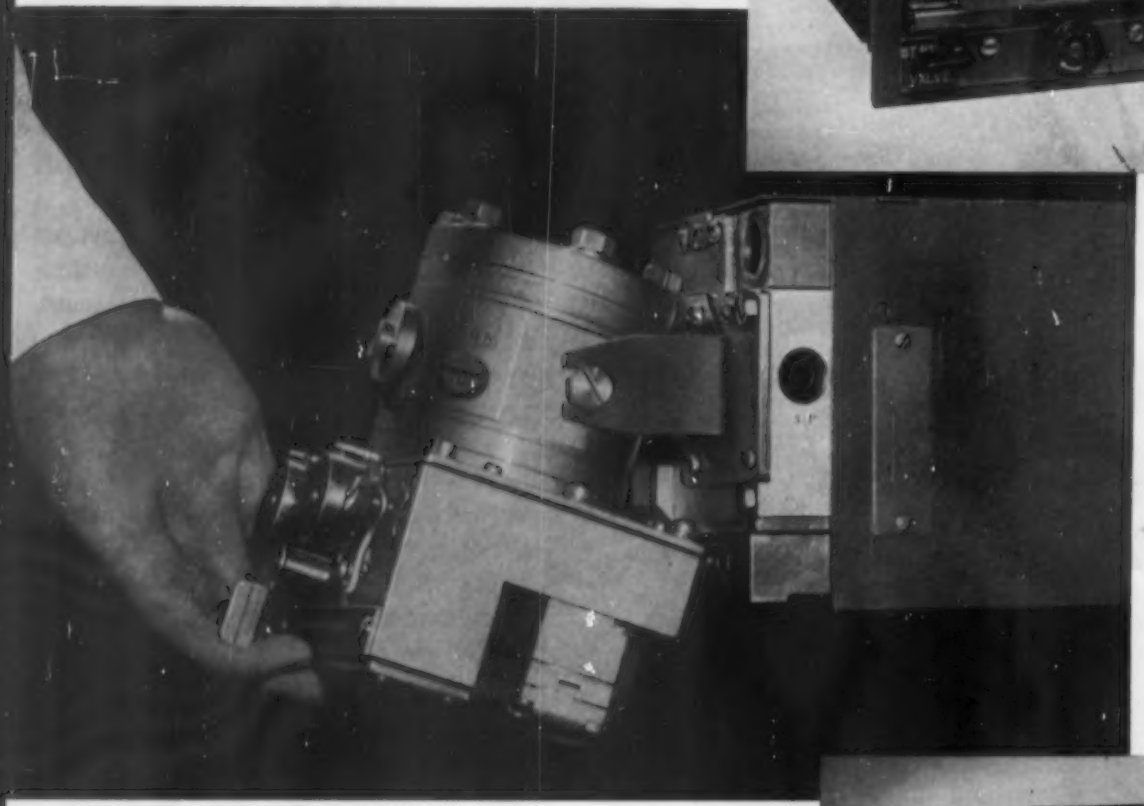
The Canadian Kellogg Company, Limited, Toronto • Kellogg International Corporation, London

SUBSIDIARIES OF PULLMAN INCORPORATED

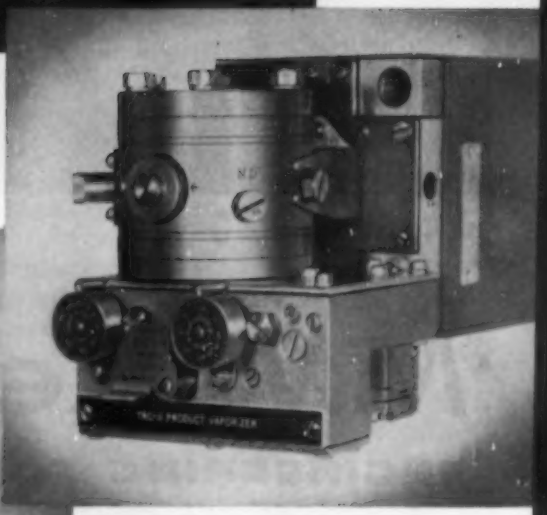
Horizontal scale above chart provides continuous indication of control air pressure to valve.

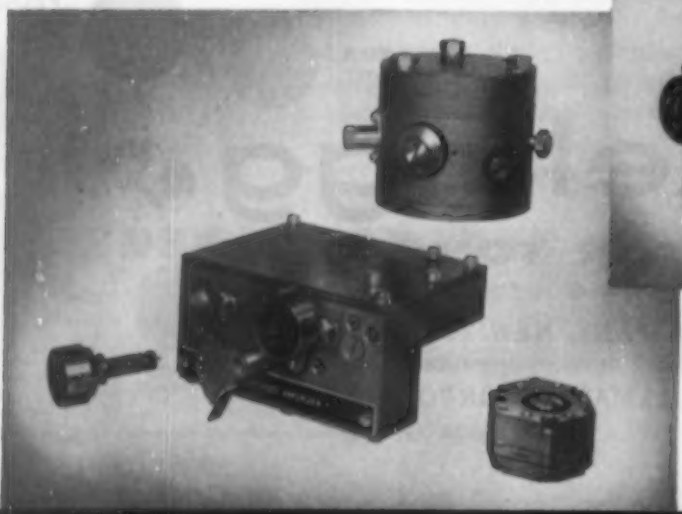


Quick-connect controller mounting . . . for added protection the controller is supported by a yoke when disconnected.



All adjustments are readily accessible from the rear of the controller.





Unitized construction of all major components simplifies maintenance . . . makes re-assembly foolproof.

Today's Tel-O-Set* instruments are easiest to install . . . operate . . . service

THE latest improvements in the *Tel-O-Set* family of miniature recorders and controllers make them the simplest and most convenient ever. Operating men, installers and service men alike will appreciate these outstanding features:

Quick-connect mounting—either on back of recorder, back of panel, or at a remote location. A single lever opens or closes all interconnecting air lines . . . allows the controller to be removed without interfering with manual control of the process.

Foolproof connect and disconnect. The rear of the recorder is a flat gasketed surface that matches up perfectly with the controller. It's completely free of any protruding valve stems or plug-in fittings that might be damaged in shipping or handling in your plant. Self-contained air switch must be shut off before the controller can be removed.

Leakproof design—with large capacity valves.

Wide range of reset rates. A single instrument provides a simple choice of three different ranges . . . fast, intermediate and slow . . . enabling one basic model to serve in applications formerly requiring several models.

Versatility. Rate action is readily added. When equipped with a manifold, the controller can be mounted remotely, either back of the panel or in the field.

Low air consumption—less than 0.2 scfm.

Unitized construction—permits fast, easy removal and replacement of major sections.

Compare the features . . . and the operating characteristics . . . of the *Tel-O-Set* line of instruments. You'll find they represent the top in value in miniature instrumentation, that will give you the top in performance and serviceability on your process control panels. For a discussion of your specific requirements, call your nearby Honeywell sales engineer . . . he's as near to you as your phone.

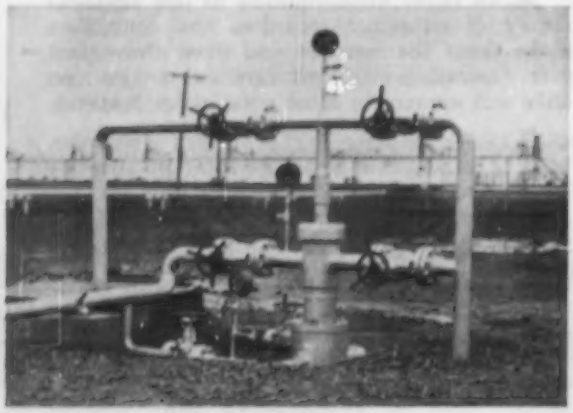
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA: Write for your copy of new Bulletin No. 7201, "Quick-Connect *Tel-O-Set* Instruments."**

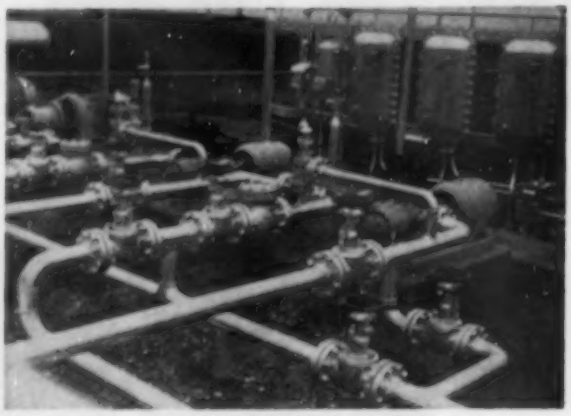
**Tel-O-Set* is a trade mark of the Minneapolis-Honeywell Regulator Co.*

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

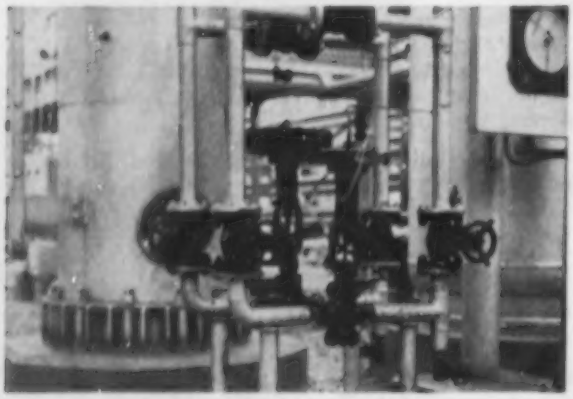
look where ORBIT VALVES are serving



Surface installations over propane underground storage well in Kansas.



Suction and discharge propane and water lines at underground storage project in Kansas.



Blending tanks. Blending 18 lb. gasoline up to 38 lbs. vapor pressure.

Manifold dome — propane surface storage.

here's how ORBIT VALVES can help reduce your operating costs

Orbit Forged Steel ASA Class Valves are *vapor tight* because:

- The body and bonnet are made of drop forged steel which greatly increases the density of the metal.
- The bonnet is welded to the body. This eliminates leaks that sometimes occur in bolted bonnet type valves.
- The stem packing chamber is equipped with adjustable plastic packing that can be added to if necessary while the valve is in service and under pressure.
- A positive seat shut-off through Orbit's principle of friction free seating.

There is Only One ORBIT VALVE

ORBIT VALVES®

ORBIT VALVE COMPANY

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(Serving West Texas)

For more data on advertised products, use Readers' Service Cards, last page.

DESIGN
ENGINEERING
PROCUREMENT
CONSTRUCTION

Under the hard hats of Procon's field personnel you'll find some of the most capable and experienced construction engineers in the world. They're practical men who know industrial construction down to the most minute detail. They've had a hand in many major construction projects. Perhaps the last one was a refinery in the Canary Islands . . . or a petrochemical plant in England . . . for Procon is international in scope. They're men who are accustomed to responsibilities . . . who know the value of time and the importance of conserving it . . . and who are ever conscious of their obligations to the client. They are playing an important part in making Procon synonymous with dependability in the field of industrial construction.

PROCON *Incorporated*

PROCESS CONSTRUCTION

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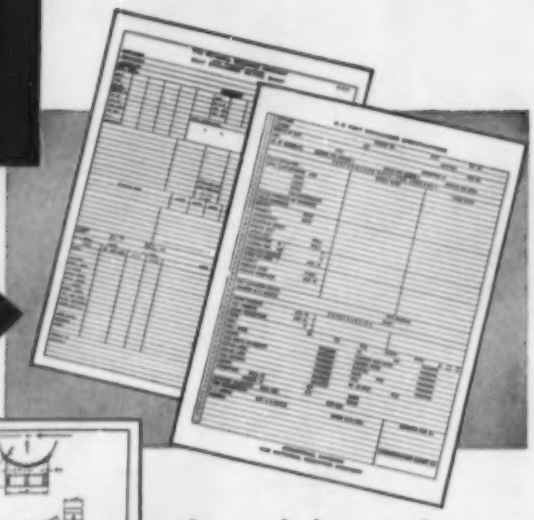
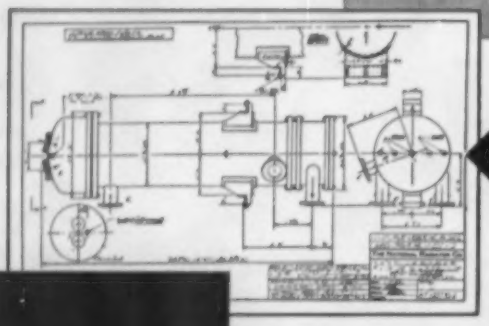
NATIONAL
SHELL and TUBE HEAT EXCHANGERS

Your heat exchanger problems will be handled completely and efficiently from individual specifications . . .





through latest design to highest standards

and careful fabrication . . .

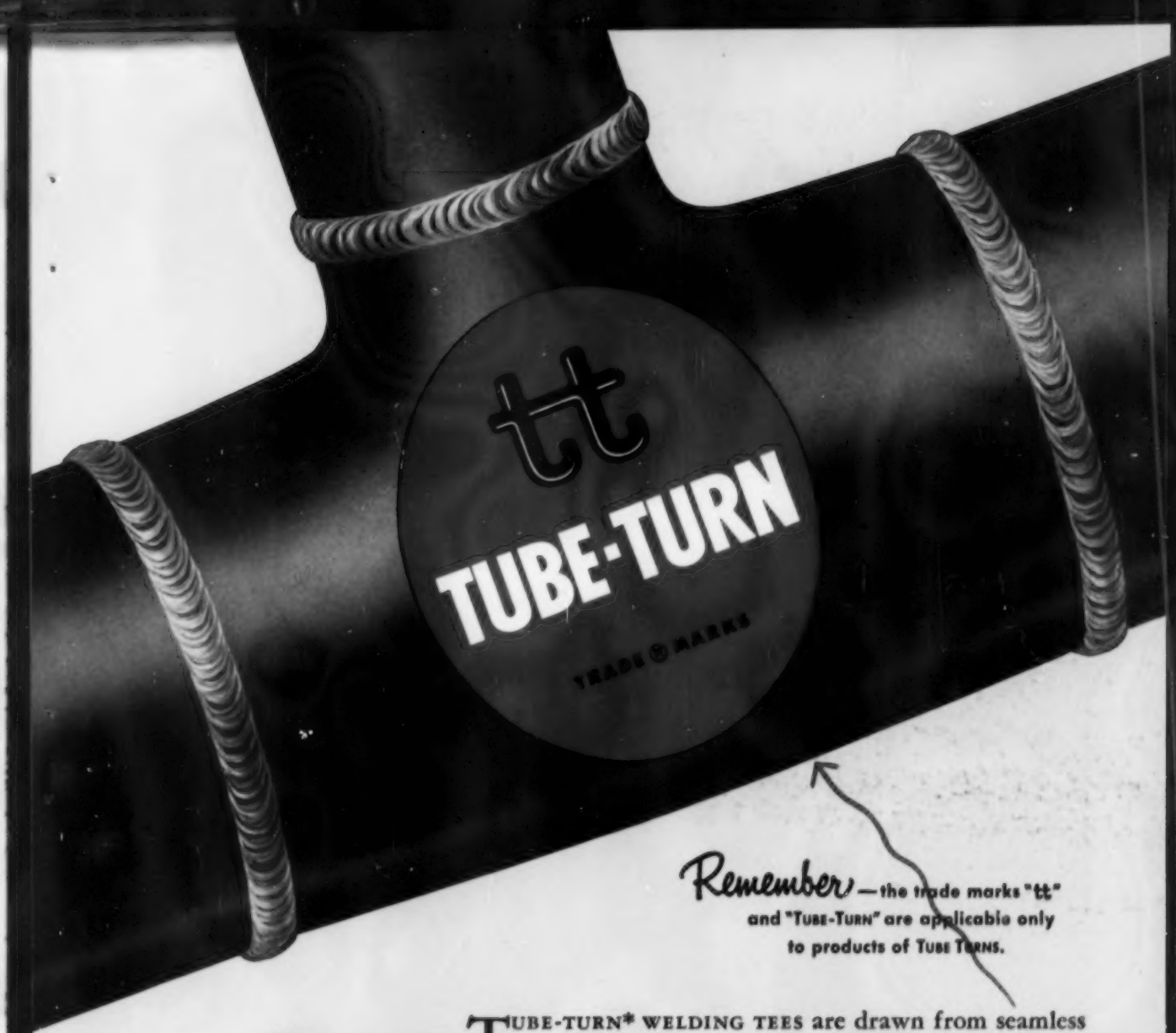
to finished product

NRC

WRITE FOR BULLETIN HT-654.

WE WELCOME YOUR INQUIRIES!

by the *Heat Transfer Division* of
THE NATIONAL RADIATOR COMPANY
JOHNSTOWN, PENNSYLVANIA
HEAT TRANSFER DIVISION HEADQUARTERS 60 East 42nd Street, New York



Remember—the trade marks "tt" and "TUBE-TURN" are applicable only to products of TUBE TURNS.

You get extra strength with *The Leading Brand*

TUBE-TURN* WELDING TEES are drawn from seamless tubing to a barrel shape. This, and other design features produce high strength—averaging over 25% more than required by applicable standards.

Specify TUBE-TURN Welding Fittings and Flanges for extra values: superior products, the exact fitting or flange you need from our complete line, outstanding engineering service. Call your nearby Tube Turns' Distributor. He is at your service!

The Leading Manufacturer of Welding Fittings and Flanges

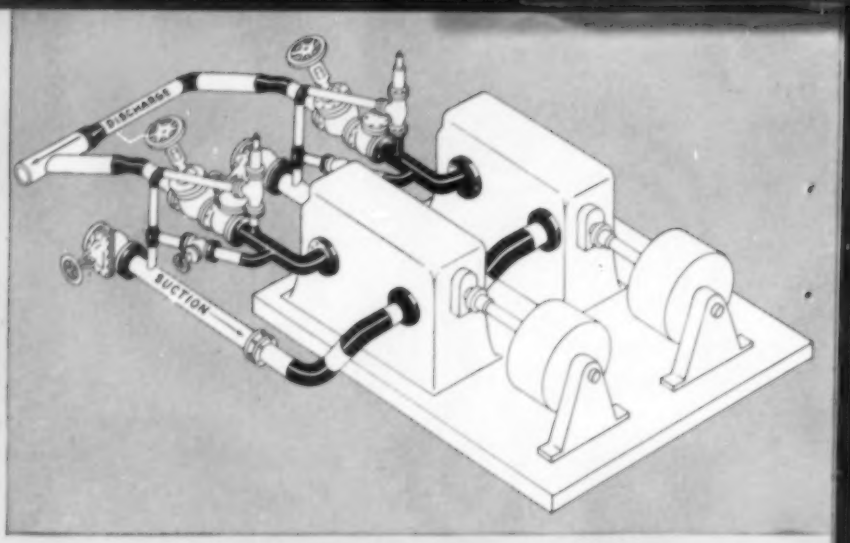
TUBE TURNS LOUISVILLE 1, KENTUCKY

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

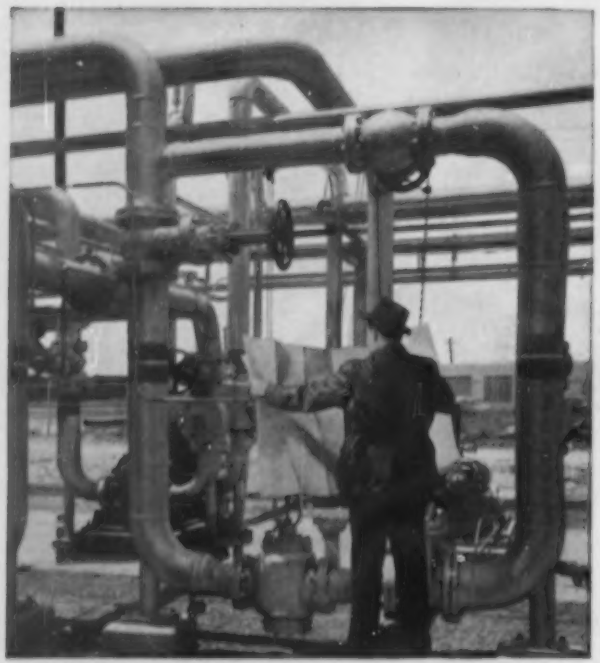
DISTRICT OFFICES: New York • Philadelphia • Cleveland • Toledo • Chicago • Denver • Los Angeles
San Francisco • Seattle • Atlanta • Tulsa • Houston • Dallas • Midland, Texas

EXTRA VALUES

Speed up your piping jobs with TUBE TURNS' SERVICE



ENGINEERING SERVICE—Tube Turns' Engineering Service can help you on your piping projects. For example: Diagram above shows an application where TUBE-TURN* Welding Fittings and Flanges simplified the design and erection of pump piping. They save time, save space, and make the piping permanently leakproof and reliable. Ask your Tube Turns' Distributor to give you the pump piping recommendations of Engineering Service.



COMPLETE LINE SERVICE—You can make sure of getting the right fitting for each job when you specify "TUBE-TURN". This is the world's most complete line of welding fittings and flanges, including more than 4000 items, in all piping materials, schedules, and sizes.

AVAILABILITY—Your nearby Tube Turns' Distributor carries local stocks for fast delivery. Call him for good service in good connections.

technical data service

Tube Turns is recognized as a leading source of authoritative information on piping design. For booklet on "Allowable Working Pressures", fill out and send the coupon now.

TUBE TURNS, Dept. Y-1
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Please send free copy of "Allowable Working Pressures"

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Company Address _____

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* "tt" and "TUBE-TURN" Reg. U.S. Pat. Off.

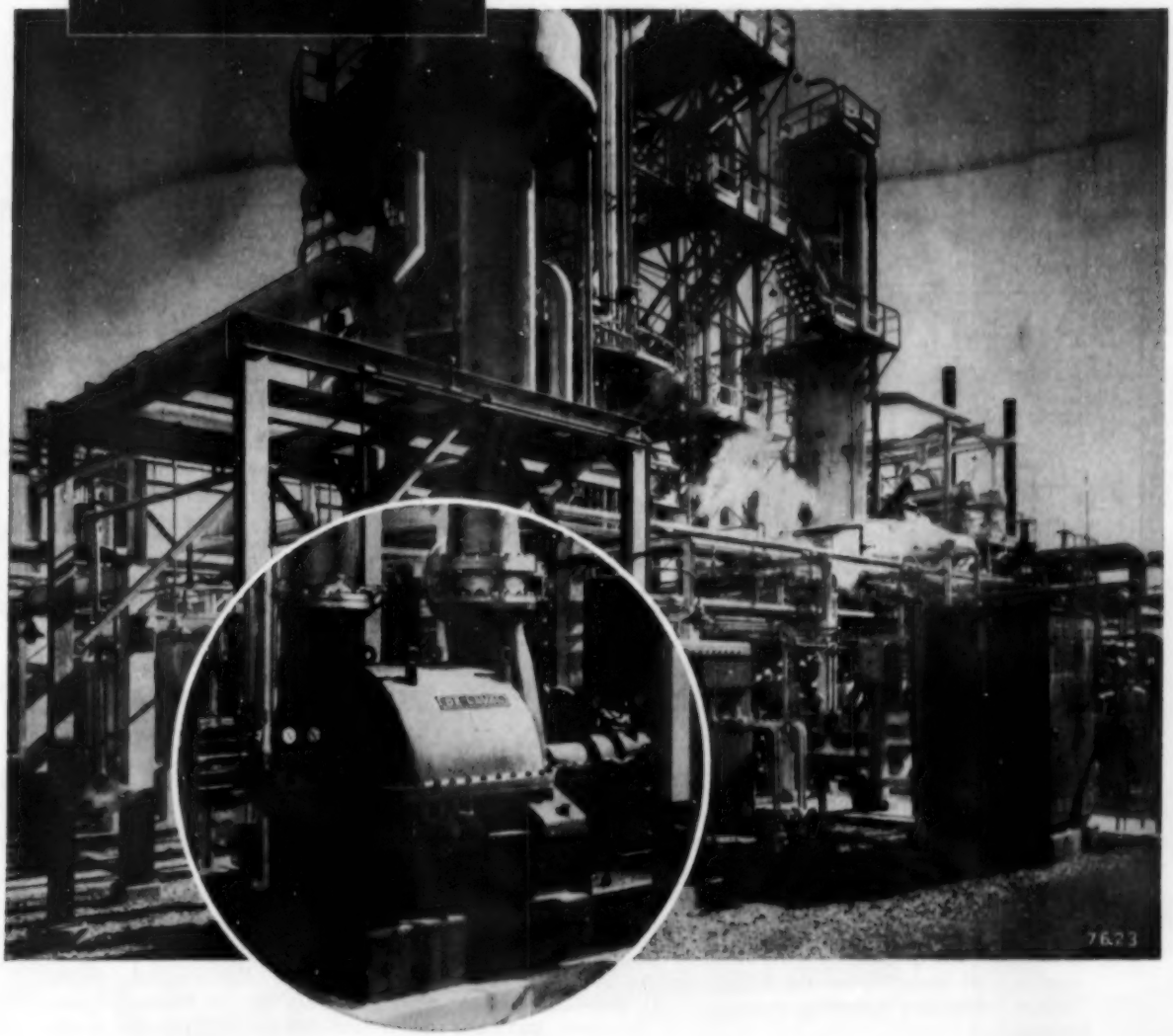
TUBE TURNS

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

LOUISVILLE 1, KENTUCKY

DE LAVAL CENTRIFUGAL BLOWER

delivers 17,400 cfm for Elreco's new cat



This De Laval Centrifugal Blower, on stream at the El Dorado Refining Company's new cat cracker at El Dorado, Kansas, supplies 17,400 cubic feet of air per minute for regeneration of the spent catalyst.

This plant, built in record time of ten months by The Refinery Engineering Company, is designed for a charge capacity of 4,300 barrels per day at 75% conversion.

Elreco is another of many refineries which have chosen De Laval for dependable blower performance under heavy-duty, continuous operation. Rugged casings, husky, perfectly balanced rotor and externally mounted, cylindrically seated bearings are design features that reduce maintenance and insure long service. Send for Bulletin 0500 containing complete data.

DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY

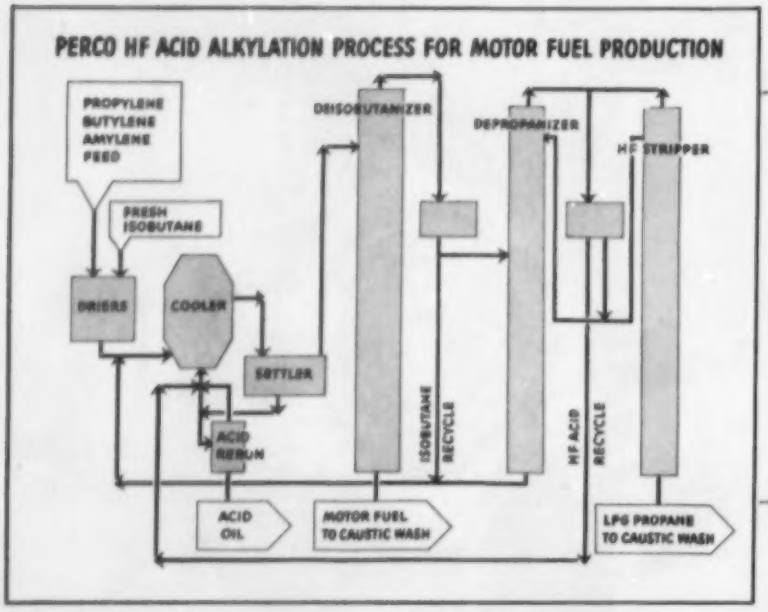
811 Nottingham Way, Trenton 2, New Jersey

DL 507

PERCO HF ALKYLATION

the economical route to

HIGHER OCTANE MOTOR FUEL



Liquid feed, containing olefins and isobutane, is passed through driers and fed into a cooler along with liquid recycle hydrofluoric acid. Hydrocarbons and recycle acid then flow to the settler. The acid phase is recycled to the cooler. The hydrocarbon phase is fractionated to separate high octane motor fuel alkylate from recycle isobutane.

● On Christmas Day, 1942, Phillips began operating the world's first HF Alkylation unit. Phillips designed this plant from data developed in Phillips laboratories and pilot plants. Today, the original unit is still operating, with its original capacity increased from 1,750 to 12,000 barrels per day.

Now, Perco Division offers refiners a simple, streamlined and thoroughly proved HF Alkylation process that incorporates the many benefits of Phillips unmatched operating experience with this process.

Construction and operating expenses are low.

Perco HF Alkylation requires no more utilities and manpower than does an equivalent cat-poly unit. Yet yield, based on olefin content, is about 2½ times better for HF Alkylation compared with catalytic polymerization. ASTM distillation final end point is appreciably lower for HF Alkylate compared to cat-poly gasoline. Furthermore, TEL and normal butane blending values are particularly attractive with motor fuel alkylate.

HF Alkylation licensed by Perco includes rights under the patents of Universal Oil Products Company and thus confers full patent protection to the licensee. Consult today with Perco about the advantages of HF Alkylation for production of higher octane motor fuels.

PERCO *Division*

PHILLIPS PETROLEUM COMPANY

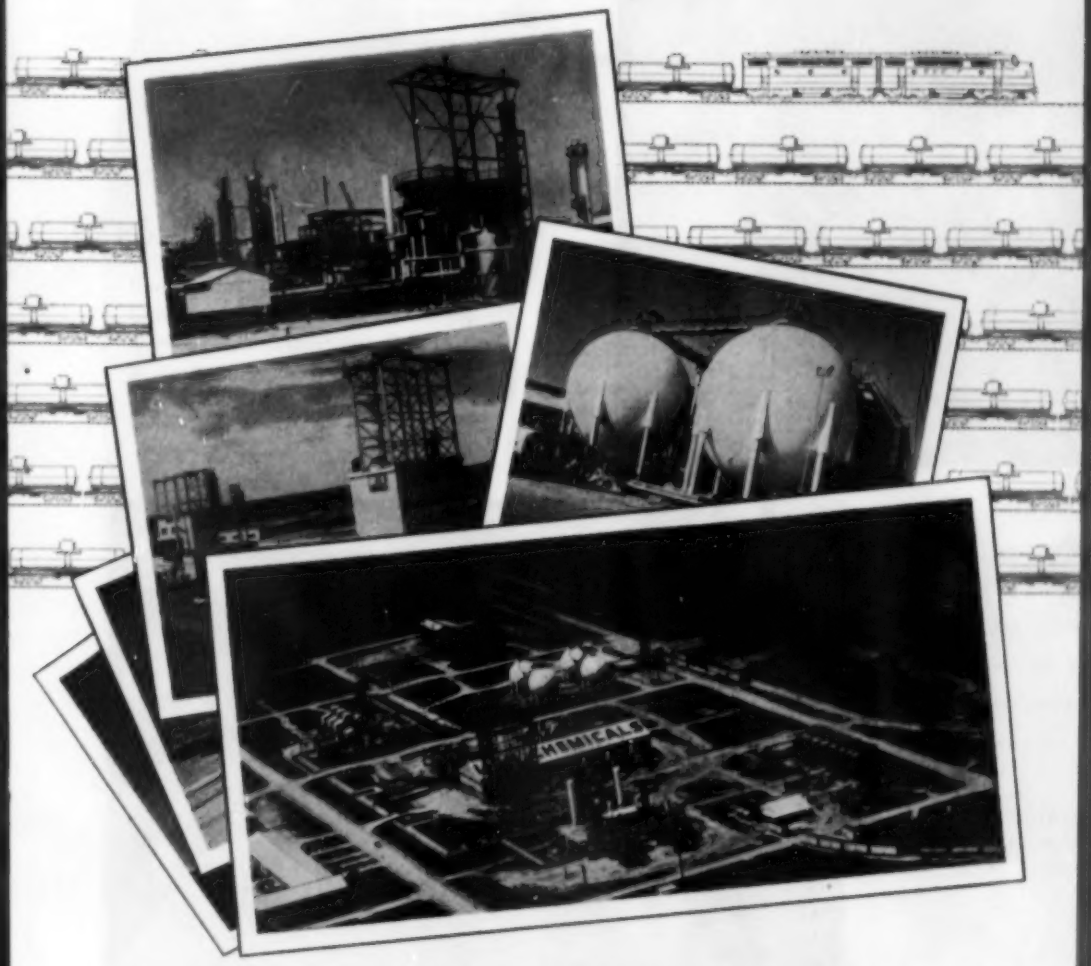
BARTLESVILLE, OKLAHOMA

PERCO ◆A SERVICE MARK

For more data on advertised products, use Readers' Service Cards, last page.

Another 1,000 tons of NH_3 per day!

added to world production
through Chemico-designed plants
completed during 1954



Ammonia plants placed "on-stream" in 1954 for **Phillips Chemical Company, Lion Oil Company, American Cyanamid Company, and Sherritt Gordon Mines, Ltd.** add more than 1,000 tons daily ammonia production to the already impressive total capacity of Chemico-designed plants.

Chemico provides a *complete* project service in designing the plant, supplying all material, and erecting structures and equipment to produce ammonia from natural gas, by-product hydrogen, or other suitable raw materials.

CHEMICAL CONSTRUCTION CORPORATION

A UNIT OF AMERICAN CYANAMID COMPANY

488 MADISON AVENUE, NEW YORK 22, N. Y.

CABLE ADDRESS: CHEMICONST, NEW YORK

TECHNICAL REPRESENTATIVES: CYANAMID PRODUCTS LTD., LONDON
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CC579

CHEMICO

CHEMICO CHEMICAL CONSTRUCTION CORPORATION

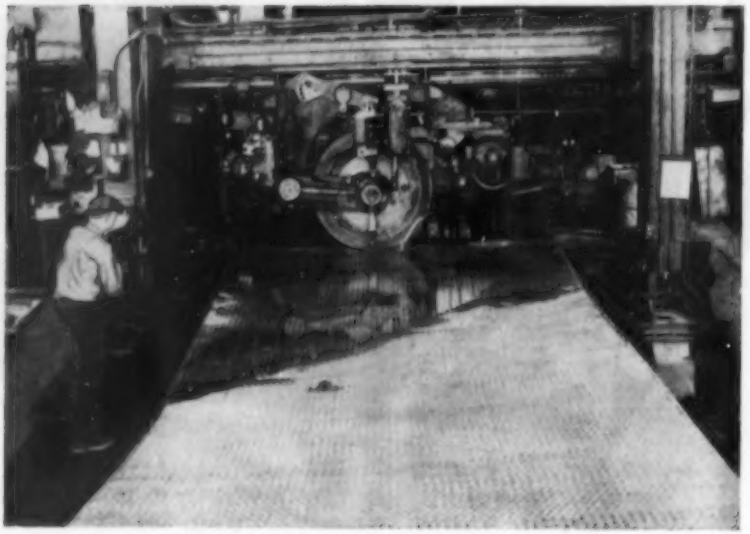
Made to Last in Severe Corrosives

A TOWER OF RESISTANCE

Strips of HASTELLOY alloy C are being arc-welded to this 44-ft. long tower to give it added corrosion resistance. The entire inside surface of the vessel is covered with ⅛-in. thick sheet.

SEALING OUT CORROSION

This lining of HASTELLOY alloy F will resist acids and alkalies. It is attached to steel by the Smithlining* spotweld process, one of the many ways of attaching HASTELLOY alloys to steel. Use of lined-sheet is an economical means of handling severe corrosives.



HASTELLOY alloys can help solve your corrosion problems, too. For further information, contact the nearest Haynes Stellite Company office.

*"Smithlining" distinguishes an exclusive process of the A. O. Smith Corporation, Milwaukee, Wisconsin.

HASTELLOY *alloys*

TRADE-MARK

Nickel-base, corrosion-resistant alloys available as sheet, plate, bar stock, welding rod, welded tubing and pipe, cast pipe and pipe fittings, sand and precision-investment castings.

"Hastelloy" is a registered trade-mark of Union Carbide and Carbon Corporation.

Haynes Stellite Company
A Division of
Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago — Cleveland — Detroit — Houston
Los Angeles — New York — San Francisco — Tulsa

ADSCO

ENGINEERED HEAT EXCHANGERS

• Whether they are manufactured to the customer's specifications or to our own recommended designs, ADSCO-Engineered Heat Exchangers are carefully designed and constructed to deliver their full rated capacity and to perform in accordance with the customer's process needs. Consult ADSCO's engineering department for recommendations, drawings or estimates on heat exchangers which meet your specific problem.

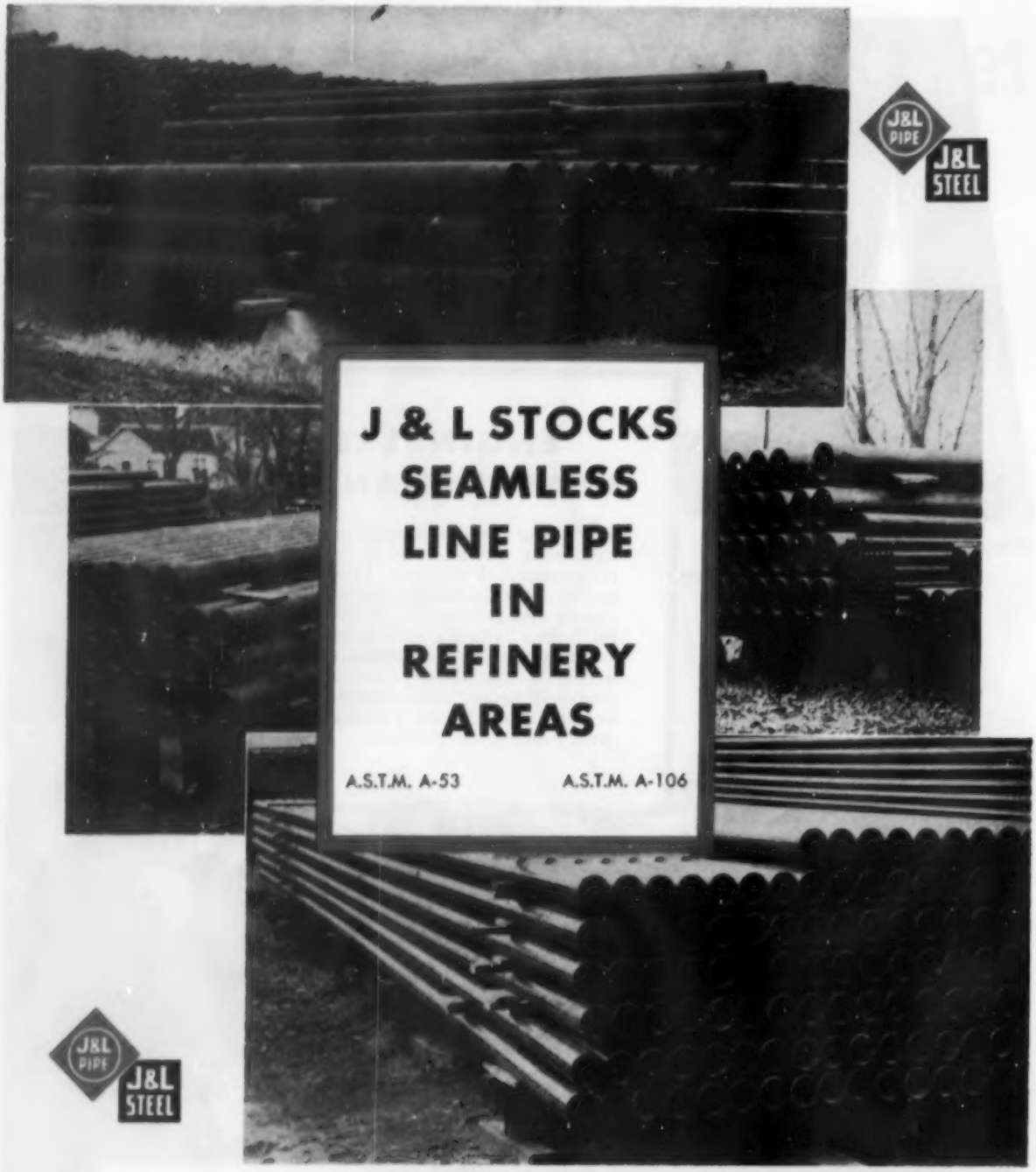
Shown above, thermosyphon reboiler; float-head, removable bundle type, for refineries at Westville, N. J., and Lawrenceville, Ill.

ADSCO ENGINEERED PRODUCTS

AMERICAN DISTRICT STEAM COMPANY, INC.

GENERAL OFFICES
NORTH TONAWANDA, NEW YORK

PLANTS
NORTH TONAWANDA, N. Y. — RICHMOND, CALIF.



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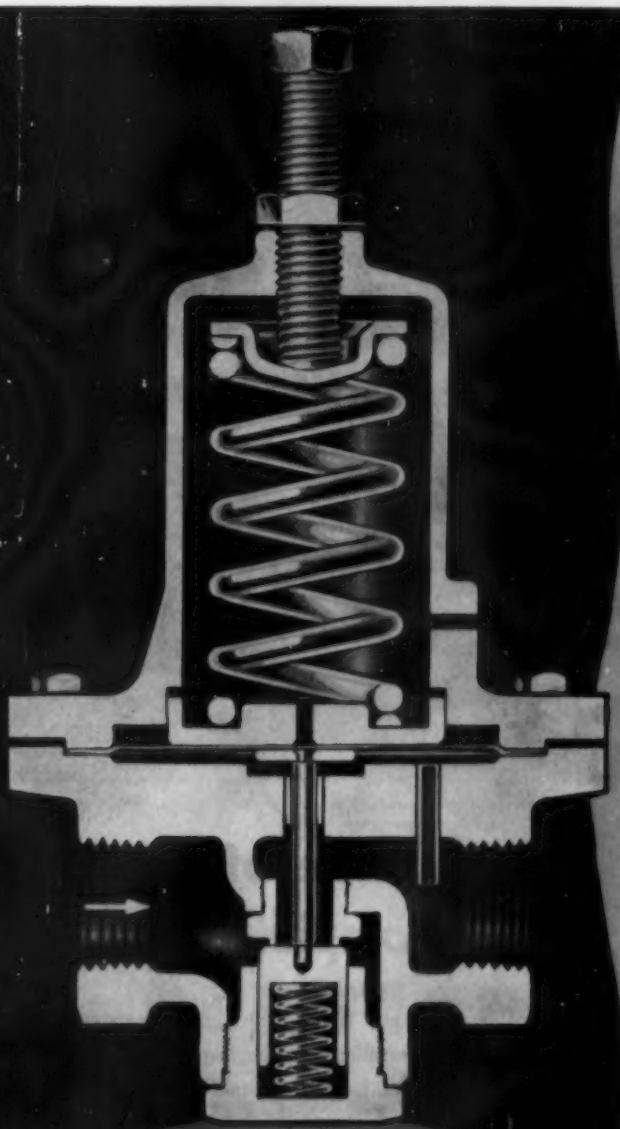
Jones & Laughlin
STEEL CORPORATION
SUPPLY DIVISION—TULSA OKLAHOMA
Serving The United States and Canada



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Series 95

SELF-CONTAINED PRESSURE REGULATOR

. . . A simple, sturdy, self-contained regulator that is suitable for steam, air, gas, oil, water and other fluids.

TYPE 95H features hardened stainless steel trim . . . flat seat . . . machine lapped seating surfaces for tight shut-off for high pressure, high temperature service.

TYPE 95L has soft seat construction for low temperature service.

Sizes: ¼", ⅜", ½", ¾", 1". Outlet pressures from 2 to 30 PSI; 15 to 150 PSI. Size for size, compare its capacity.

Write for Bulletin C-95.

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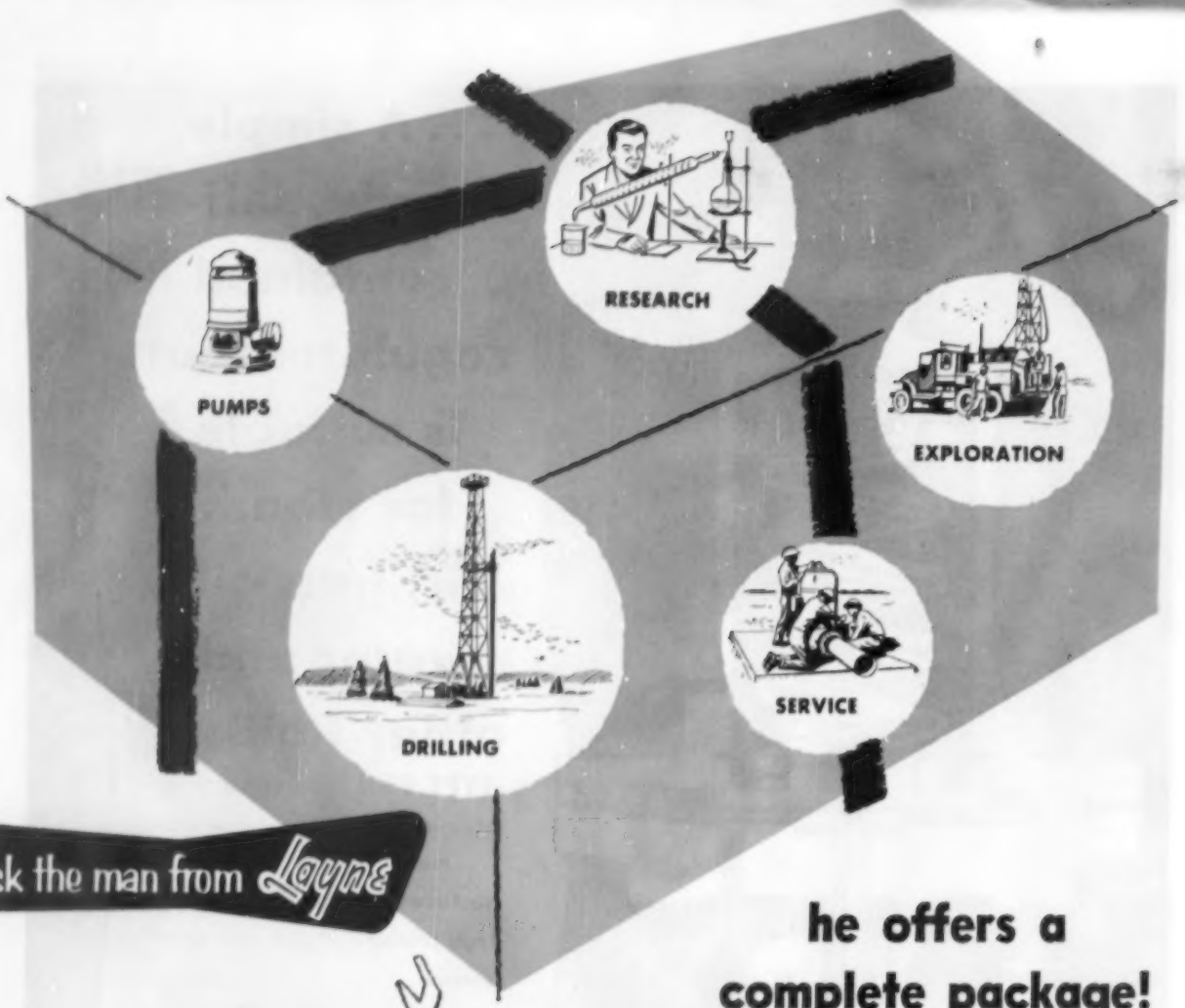

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There is no "buck passing" on a Layne job. From exploration to continuing, ever responsible service, Layne offers undivided responsibility on every job Layne undertakes.

This completeness of Layne service is one major reason why Layne has been the selection of so many top flight industries. And that over all responsibility is just as important to municipalities, large and small, as to agriculture. On anything that relates to any phase of water—"ask the man from Layne."

Layne Associate Companies Throughout the World

LAYNE & BOWLER, INC.
Memphis 8, Tennessee

water wells • vertical turbine pumps • water treatment

This modern parts warehouse is typical of the complete facilities available to service your Cooper-Bessemer equipment.

Another Example of Efficient Power at Lower Cost

WITH COOPER-BESSEMER...

SERVICE for the life of your engine

When you invest in Cooper-Bessemer engines or compressors, skilled technicians are only as far away as the telephone. It is their job to see that the installation is "right" in every detail . . . . that it continues to operate at top efficiency.

To aid in this program, Cooper-Bessemer has strategically located service warehouses which offer prompt delivery of any needed replacement part. You don't have to stock an expensive or extensive parts inventory, as Cooper-Bessemer factory parts will always be available . . . even if the engine is no longer in production.

Cooper-Bessemer also offers the helpful problem-solving experience of its engineering department and field service engineers as changed conditions or new requirements arise.

If your power problems fall within the 200 to 5000 hp range, reliable Cooper-Bessemer Diesels, gas engines and heavy-duty compressors offer the economical and long-lived answer . . . and with the best of service always at your command.

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GROVE CITY, PENNA.

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DIESELS • GAS-DIESELS • GAS ENGINES • ENGINE-DRIVEN AND MOTOR-DRIVEN COMPRESSORS

For more data on advertised products, use Readers' Service Cards, last page.

—to protect the quality of your gasoline

On-the-spot technical assistance helps you take full advantage of Tenamene

Inhibitor response is closely tied to many variables. These include the nature of the crude, the character of the stock fed to cracking units, operating conditions, equipment performance—even employee carelessness.

Proper and economical use of inhibitors depends on quick adjustments to these changing conditions. On-the-spot service often is a "must."

As the producer of the Tenamene additives, Eastman is ready with that service whenever and wherever you need it. Highly qualified men are less than 24 hours away, ready to make your refinery their headquarters whenever a problem arises.

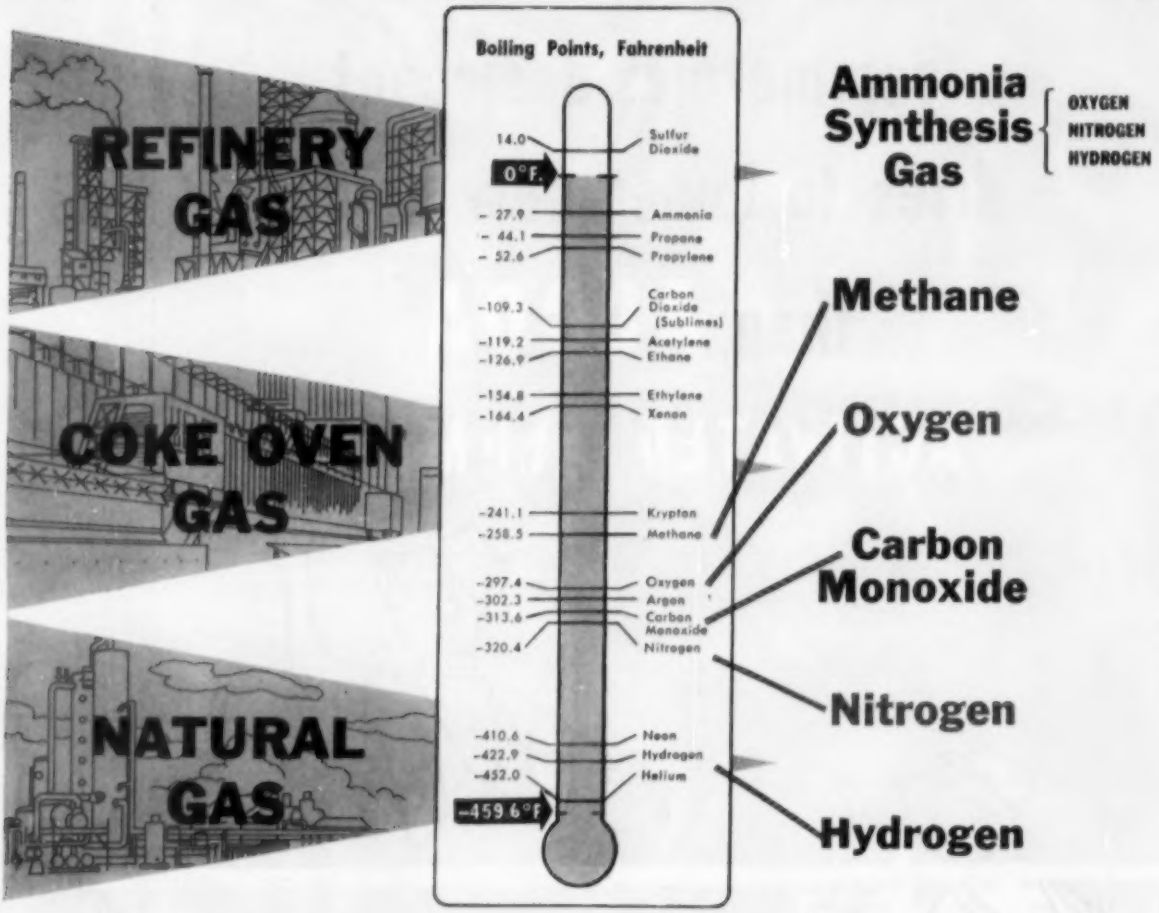
For more information on Tenamene additives and the interested technical service that backs up their proper use, contact our local representative or write to Eastman Chemical Products, Inc., Kingsport, Tennessee—a subsidiary of Eastman Kodak Company.

SALES OFFICES: Eastman Chemical Products, Inc., Kingsport, Tenn.; New York—260 Madison Ave.; Framingham, Mass.—65 Concord St.; Cincinnati—Carew Tower; Cleveland—Terminal Tower Bldg.; Chicago—360 N. Michigan Ave.; St. Louis—Continental Bldg.; Houston—412 Main St. **West Coast: Wilson Meyer Co.;** San Francisco—333 Montgomery St.; Los Angeles—4800 District Blvd.; Portland—520 S. W. Sixth Ave.; Salt Lake City—73 S. Main St.; Seattle—821 Second Ave.

Tenamene

EASTMAN GASOLINE ADDITIVES

HYDROCARBON SEPARATION
by Low-Temperature Processing



IF YOUR COMPANY is among the many who are looking into the extra profit possibilities "hidden" in your fluid flows or by-product gases, in natural gas or in the air itself—check with *Air Products.* The low-temperature route is proving to be the most profitable for more and more separation processes. For example, many ammonia manufacturers — both petro-chemical and coal chemical—are using low-temperatures to produce oxygen and nitrogen . . . purify hydrogen . . . recover valuable by-product hydrocarbons.

Ask *Air Products* to investigate the possibilities of your hydrogen, hydrocarbon-rich streams. Leader in its field, *Air Products* has designed and built close to 700 low-temperature gas separation plants. Our more than 100 engineers are at your service. We can supply a preliminary engineering analysis, or a complete process design. Outline your problem to us—your inquiry will incur no obligation. *Air Products, Inc., Dept. X, Box 538, Allentown, Pa.*

36-page BROCHURE explores the broad possibilities of low-temperature processing . . . illustrates *Air Products'* facilities. Write for a free copy.

Air Products
INCORPORATED
Specialists in Low-Temperature Processing

Cost Analyses • Process Design • Apparatus Design • Apparatus Manufacture

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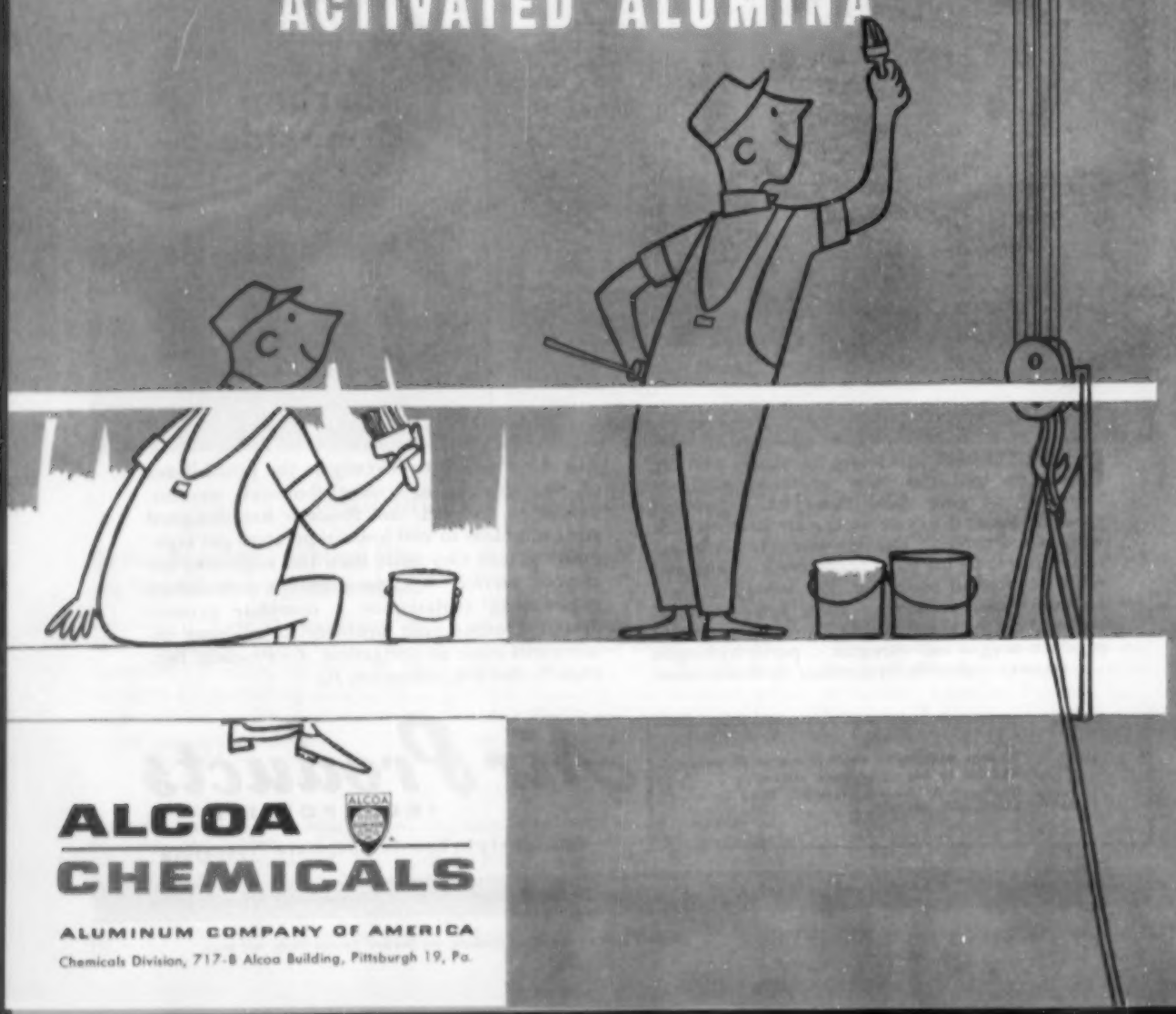
No other commercial desiccant dries to lower dew points than ALCOA ACTIVATED ALUMINA



ALCOA CHEMICALS

ALUMINUM COMPANY OF AMERICA

Chemicals Division, 717-B Alcoa Building, Pittsburgh 19, Pa.

Insulation is snapped on 8" pipe

Staples are used to close seam

Texas City Chemical Company takes advantage of —

LOWER HEAT LOSSES, LOWER COST

with new G-B SNAP*ON Pipe Insulation

Company saves 32,000 Btu per hour, with ½" less wall thickness

Problem: Over 1700 feet of pipe that was to carry steam or molten sulfur at temperatures up to 300° F. had to be insulated at Texas City Chemical Company's new dicalcium phosphate and sulfuric acid plants at Texas City, Texas.

Solution: Company's chief engineer approved G-B Snap*On glass fiber insulation, when calculations showed less heat loss at a lower material cost than another widely-used insulation material.

The pipe insulation, composed of fine glass fibers bonded with phenolic resin, was supplied in standard one-piece sections six feet in length. It was spread apart at the seam and snapped-in-place on the pipe. Results: Besides material and heat savings, the insulation contractor (Precision Insulating Co.) reports that the applied costs were 20% less than the job estimate (based on time standards for other insulating materials).

At 300° F. mean temperature, the heat loss comparison was calculated for the job. (See table.) At this temperature, a savings of over 30,000 Btu per hour was found. This improved insulation performance resulted even with ½" less wall thickness.

As the insulation did not chip, break, or crumble, no tailings were left around installation area.

G-B Snap*On glass fiber pipe insulation is available in sizes that will fit pipe from ¾ inch to 33 inches nominal diameter, inclusive.

Write today for samples and full details or call G-B Snap*On distributors (in the Yellow Pages) who carry local stocks in 72 cities.

Heat Loss Comparison

Snap*On vs Competitive Insulation

Nominal pipe size	Length (ft)	Competitive insulation thickness	Btu/ft loss (300°F)	G-B Snap*On insulation thickness	Btu/ft loss (300°F)	Total Btu savings per hr
8"	444	2	120	1½	91	12,876
6	6	2	97	1½	76	126
4	300	2	73	1½	53	6000
3	582	1½	73	1½	59	8148
2	432	1½	55	1½	43	5184
	1764					32,304

GUSTIN-BACON *Manufacturing Company* gb

Thermal and acoustical glass fiber insulations • Pipe Couplings and fittings • Railroad gaskets and supplies

242 W. 10TH ST., KANSAS CITY, MO.

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TAKE OUT THE SALT AND THE RISK...

with **Visco**

DESALTING TREATMENT

● Visco Desalting Treatments are your assurance of maximum salt removal and minimum risk of deposits, or plugged equipment. Used alone, or with electrical desalting, Visco formulas consistently and economically produce low salt content crude.

Your Visco Representative will be available whenever you call. Ask for his recommendations for better operation and lower treating cost. For fastest action call collect to Houston, Madison 0433, today.

VISCO PRODUCTS COMPANY
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Visco... CONSISTENTLY EFFICIENT OIL INDUSTRY CHEMICALS

DEKORON INSTRUMENT TUBING

knocks out your instrument line corrosion problems

DEKORON single-line tubing. Samuel Moore & Co. will coat your copper, aluminum or steel tubing by the Dekoron extrusion process, or will supply coated tubing. Straight lengths to 20 ft., coils to 1000 ft.

DEKORON IMPERVAPAK is a multiple tube harness of plastic or metal tubes encased in tight plastic sheath. Multiple tube construction cuts down installation costs.

Corrosion endangers the life line of your plant—your instrument tubing. That's why you should investigate Dekoron instrument tubing, the tubing that's impervious to moisture, salt air, corrosive atmospheres, and chemicals.

That means Dekoron eliminates replacement costs and maintenance. Other advantages are low initial cost . . . less plant down time . . . easy installation with standard fittings and plastic tape.

In replacement savings alone—not including lower maintenance and installation costs—Dekoron Instrument Tubing pays for itself over and over again.

AA-700

Send for free copy of Bulletin L-6506 "3 Ways to Whip Corrosion and High Tubing Installation Costs in Your Plant."

Dekoron® products

QUALITY • RESEARCH • SERVICE

SAMUEL MOORE & COMPANY

DEKORON PRODUCTS DIVISION

MANTUA, OHIO

For more data on advertised products, use Readers' Service Cards, last page.

Welded-In Tubes in High Pressure Service... 7 years without a failure

One of the greatest problems in operating high pressure feedwater heaters in modern super-pressure power plants is failure of expanded tube joints. In 1947, Lummus pioneered the field in *welding* monel tubes to steel tube sheets in feedwater heaters. Two such units were built for the city of Lansing, Michigan, designed for 1200 psi. These units have had no failures in seven years of operation.

Lummus now has developed a procedure of welding copper nickel tubes to steel tube sheets. Subjected to terrific pressure and temperature tests, the welded units have gone through many cycles with excellent results. Lummus has also made one installation, in service now for over six months without a failure, having a design pressure of 2900 psi, and requiring over 30,000 70-30 cupro nickel tubes welded into steel tube sheets.

The unit shown above, with a design pressure of 2,600 psi, is being fitted with 70-30 cupro nickel tubes. Successful installations have also been made with 80-20 cupro nickel tubes.

Welding-in of tubes eliminates the possibility of tube joint failure because of fabricating inaccuracies, tube irregularities, nickel oxide deposits from annealing operations, and excessive tube hardness. Welding-in makes possible the use of heavy wall tubes which cannot be satisfactorily expanded.

Your inquiries are invited.

THE LUMMUS COMPANY, Heat Exchanger Division: 385 Madison Avenue, New York 17, N. Y.
Atlanta • Boston • Chicago • Rock Island • Cincinnati
Detroit • Houston • Tucson • Tulsa • Salt Lake City
Minneapolis • Pittsburgh • Rochester • Albany
St. Louis • San Francisco • Wayne (Phila.) • Athens
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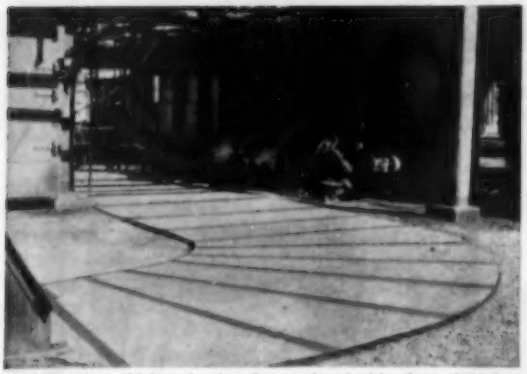
Steam Surface Condensers • Evaporators • Extraction Bleeder Heaters • Steam Jet Air Ejectors • Steam Jet Refrigeration • Barometric Condensers • Heat Exchangers for Process and Industrial Use • Process Condensers • Pipe Line Coolers.

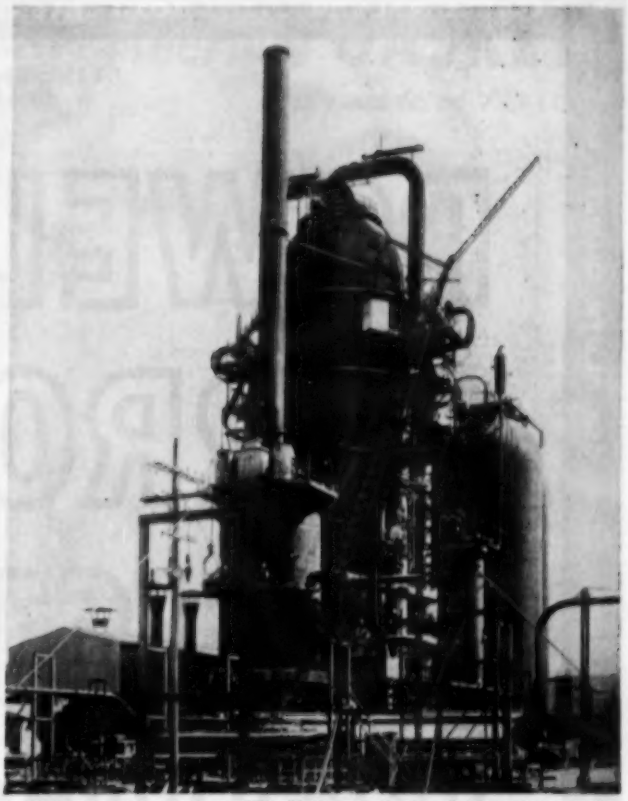
LUMMUS

THE LUMMUS COMPANY HEAT EXCHANGER DIVISION, 385 MADISON AVE., NEW YORK 17, N. Y.



ADAPTABLE – Although the flat arch of this flue (interior shown below) curves alongside the coke still, construction was fast and simple with Lumnite-made industrial concrete.

TROUBLE-FREE SERVICE – Interior of heat-resistant flue is in excellent condition after ten years of service at 1000° F.



LONGER-LASTING LININGS—This Kellogg Orthoflow fluid catalytic cracking unit is lined with a Lumnite-made refractory insulating concrete.

SPECIAL INDUSTRIAL CONCRETES made with LUMNITE*

cut costs and improve efficiency throughout the plant

If you have a heat, corrosion or insulation problem at your refinery, chances are that Lumnite calcium-aluminate cement can help solve it. That's because special industrial concretes made with Lumnite cement are actually three-in-one concretes. They not only resist heat and corrosion, *they insulate at the same time.*

Versatile industrial concretes made with Lumnite cement are quickly placed – by cement gun, troweling or pouring – and they reach service strength within 24 hours! Downtime is reduced, labor costs are cut, and production losses are kept to a minimum.

For added convenience, you can use prepared castables (packaged mixes of Lumnite cement and aggregates selected for specific temperature and insulation requirements – add only water). They're made and distributed by leading manufacturers of refractories. For more information, write Lumnite Bureau, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, New York.

USE SPECIAL INDUSTRIAL CONCRETES FOR

1. **REFRACTORY INSULATING CONCRETE** – in strippers, rerun chambers, reactors, regenerators, fractional distillation and thermal alkylation units.
2. **ABRASION-RESISTANT REFRACTORY CONCRETE** – Catalyst transfer and discharge lines, reforming chambers, gas coolers, reactor cyclones and transfer lines, regenerator cyclones and return lines.
3. **REFRACTORY CONCRETE** – in bubble and flash towers, continuous-pressure stills.
4. **CORROSION-RESISTANT AND REFRACTORY INSULATING CONCRETE** – linings in regenerator exhaust lines, stacks, ducts.
5. **CORROSION-RESISTANT CONCRETE**—in linings for sweetening and storage tanks, waste-disposal systems, and trenches.

OFFICES: *Albany, Birmingham, Boston, Chicago, Dayton, Kansas City, Minneapolis, New York, Philadelphia, Pittsburgh, St. Louis, Waco.*

**"LUMNITE" is the registered trade-mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.*

PR-L-101

ATLAS® **LUMNITE for INDUSTRIAL CONCRETES**

REFRACTORY, INSULATING, OVERNIGHT, CORROSION-RESISTANT

A UNIVERSAL ATLAS PRODUCT

UNITED STATES STEEL HOUR – Televised alternate weeks – See your newspaper for time and station.

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. . . THE COMPLETE QUALITY LINE . . . POWELL VALVES . . . THE COMPLETE QUALITY LINE . . .

FIG. 2342—Flanged End Bolted Cap Swing Check Valve for 150 Pounds W.P.

POWELL CORROSION RESISTANT VALVES

FIG. 2495—Double Disc Flanged End O.S.& Y. Gate Valve for 150 Pounds W.P.

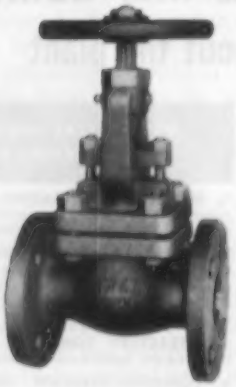

FIG. 2475—Stainless Steel O.S.& Y. Globe Valve for 150 Pounds W.P.

FIG. 3003SS—High Pressure Service Alloy Steel Gate Valve for 300 Pounds W.S.P.

POWELL VALVES . . . THE COMPLETE QUALITY LINE . . . POWELL VALVES

Powell can supply exactly the corrosion resistant valves you need . . . in a WIDE VARIETY of metal and alloys and all designs. You can be certain that every Powell Valve will give you dependable flow control.

Shown above are a few Powell Corrosion Resistant Valves. Investigate these . . . and the *complete* Powell line of quality valves that have a proven record of long, dependable service.

If no distributor is near you, we'll be pleased to tell you about our complete line, and help solve any flow control problem you may have. Write . . .

The Wm. Powell Company, Cincinnati 22, Ohio . . . . . 109th year

The Mail Box . . .

Cites Errors

To The Editor:

Your June, 1954 issue presents an article entitled: "Physical Properties of Adsorbents and Catalysts" by Felix Heinemann and Heinz Heinemann. Since I am presently engaged in work involving porous materials, I was disappointed to find in Table 1, "Densities, Surface and Pore Properties of Adsorbents and Catalysts," what appear to me to be numerous errors, some of them of such a magnitude as to render the data of little value as published.

I did not have immediately available, some of the original articles referred to, and in other cases, some of the original data had to be recalculated to obtain the form used in the current article. Some of the samples I did not find in the references given in Table 1. By recalculating and comparing the available data, I believe there are three types of errors involved:

1. Errors in the original publication. Some appear to be mistakes in calculations, while at least one might be transposition of digits. Since these occurred in the original publication it is not difficult to see how they might be repeated in the present article, even though one (H. H.) of the authors of this article was a co-author of some of the earlier publications referred to.

2. Error in calculation. In one case in which the percent pores were not given in the original, the present authors' calculated value is so obviously wrong it is difficult to see how it could have been overlooked by them.

3. Errors where the present paper does not agree with the original published data. Many of these appear, but fortunately most of them are of small magnitude. Even though the authors may not consider the data to be of great accuracy, I feel that the published data should at least be consistent with the original.

I am attaching hereto a table (see page 239), largely self-explanatory, giving the original published data (as far as I found them), the values as given in PETROLEUM REFINER, and the results of my calculations based on the original (where available) published density data. The few figures given in parenthesis were not given in the original publication, but were calculated by me from the other data given.

I would greatly appreciate receiv-

New... FreeFlow GASKETS

JOHN CRANE

made of TEFLON*

"JOHN CRANE" FreeFlow Construction
Gasket flush with pipe I.D.—allows completely unrestricted flow.
No air pocket—insert flush with I.D. of envelope. No danger of rupture due to expansion of entrapped air at high temperatures.
AIR
Ordinary "Wishbone" Construction
Envelope extends beyond I. D. of pipe, causing flow restriction and turbulence.
Expansion of entrapped air at high temperatures presents danger of gasket rupture.

FOR EVERY CORROSIVE SERVICE

"John Crane's" FreeFlow construction and chemically inert Teflon have been combined as *the* answer for gaskets in corrosive service. This new construction assures a flush fitting with the I.D. of the pipe and the inner wall of the Teflon envelope, not possible with the ordinary "wishbone" type gasket. (See drawing above).

This means elimination of:

1. Flow restriction and turbulence in the line.
2. Danger of rupture at high temperature due to entrapped air between gasket insert and Teflon envelope.

"John Crane" Teflon FreeFlow gaskets are impervious to practically every known chemical or gas and are unaffected by temperatures from −100° to +482°F., depending on the insert material. They are available in all shapes and sizes for a wide variety of applications, such as glass lined, porcelain, pyrex and similar equipment, including reactor kettles and pipes, distillation columns and nozzles.

Request full information on "John Crane" FreeFlow gaskets for your particular requirement. Ask for our informative booklet, *The Best in Teflon*, for other important technical and application data. Crane Packing Company, 1820 Cuyler Avenue, Chicago 13, Illinois. *In Canada: Crane Packing Co., Ltd., 617 Parkdale Ave., N., Hamilton, Ont.*

DEPEND ON "JOHN CRANE" TEFLON PRODUCTS

*DuPont trademark

JOHN CRANE CRANE PACKING COMPANY 38 YEARS INDUSTRIAL PROGRESS

For more data on advertised products, use Readers' Service Cards, last page.

Petro-Chem Development Company Reports:

No Shutdowns *for* Refractories Maintenance

IN OVER

1200 FURNACES

In 1940, the Petro-Chem Development Company lined their first Iso-Flow furnace with B&W Insulating Firebrick. Today, over 1200 installations later, (some with fluid outlet temperatures over 1600F) not a single furnace has ever been shut down because of the need for refractory maintenance.

Long life is just one reason furnace builders, as well as furnace operators, insist on B&W IFB. Here are four more:

CUT INSTALLATION COSTS

B&W Insulating Firebrick are easy to install. They can be cut, drilled or shaped on the job with ordinary woodworking tools. Their lightness makes them easy to handle.

ELIMINATE EXPENSIVE ALLOYS

Because of their high insulating values, B&W Insulating Firebrick can be supported or anchored with ordinary carbon steel. Expensive, heat-resisting alloys are not necessary.

REDUCE DOWN-TIME

These brick have low heat storage, cool off quickly. This makes possible quick access to the furnace for inspection. They heat up quickly to get back on the line, too.

CLOSE TEMPERATURE CONTROL

Due to the low heat-storage capacity of B&W IFB, their hot-face temperature responds quickly to changes in the rate of heat input to the furnace — insuring the closest possible temperature control.

You, too, can profit by this four-way economy of B&W Insulating Firebrick. Ask your B&W representative for all the facts on these cost-cutting refractories. He'll be glad to discuss your refractory problems with you.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

B&W REFRACTORIES PRODUCTS — B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick B&W Refractory Castables, Plastics and Mortars • OTHER B&W PRODUCTS—Stationary & Marine Boilers and Component Equipment... Chemical Recovery Units . . . Seamless & Welded Tubes . . . Pulverizers . . . Fuel Burning Equipment . . . Pressure Vessels . . . Alloy Castings

The Mail Box . . .

ing comments on this subject from all concerned.

S. W. Glass
National Carbon Research Laboratories,
Cleveland, Ohio

From Mr. Heinemann

In the second paragraph of his letter Mr. Glass states that he did not find some of the samples in the references given in Table 1. In all cases in which no references are given the published data are original work not previously published.

Concerning the alleged error in calculation for the "% Pores for Diatomaceous Earth," this is actually a typographical error which was not caught on proof reading. I agree that this is an unfortunate oversight.

The numerous alleged errors marked by Subscript 3 in which the present paper does not agree with the original published data fall in several groups. One (true density of bauxite at 1300°) is a printing error. The bulk densities for Fuller's earth which do not agree with the original publication as well as the true densities for Fuller's earth represent newer values which are an average of a great many data obtained and which I believe are more accurate than those previously published. Perhaps this should have been pointed out in a footnote to the article in PETROLEUM REFINER. On the basis of these new values, the data for "% Void" given in the article are correct. Concerning the data on Bone Char, the data given in the article are correct and are based on a private communication from Dr. E. B. Barrett containing a table (see below).

Some Physical Properties

Properties and Units	Bone Char
1. Heat of wetting (cal./g. at 70-72 F.)	15.9
2. Thermal Conductivity (Btu./ft. hr. °F at 90-210 F.)	0.100
3. Specific Heat (Btu./lb. °F. at 80-900 F.)	0.24
4. Bulk Density (lbs./ft.³ at room temp.)	38—42
5. True Specific Gravity (g./ml. at room temp.)	2.8
6. Total Pore Volume (ml./g. at room temp.)	0.28—0.32
7. Void Volume (as % of total at room temp.)	47—48
8. Specific Surface (m^2/g. BET)	100—120

We should perhaps have mentioned under References 2 and 3 that additional data from a private communication were used.

The errors marked by Dr. Glass fall into several categories. We have now checked those with a superscript 1, stated to be errors in the original publication. We find that all our basic data published in *Ind. and Eng.*

See HEINEMANN, Page 239

Killing FIRE Through Research

Fire tests like that shown above are commonplace to the specialists directing operations at "Automatic" Sprinkler's Technical Laboratory and Fire Testing Department. Determining methods to lick fire before it gains headway, is their daily task.

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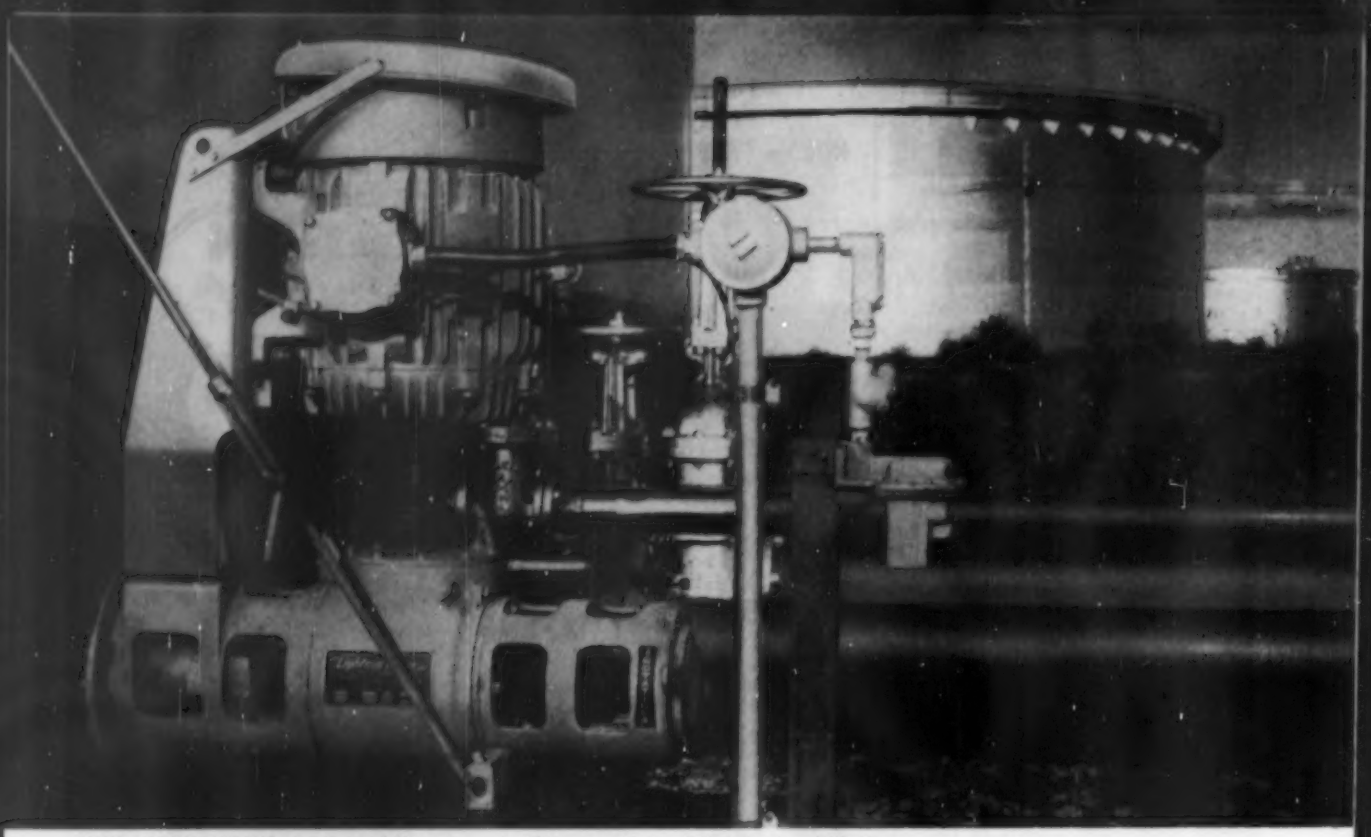

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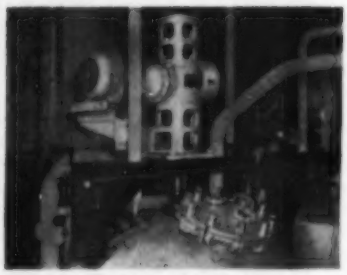

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The LOOK BOX for February . . .

Oil's Stake in CIO-AFL Merger

THE proposed merger of the CIO and AFL contains some curious implications of enormous significance to oil.

Largest organization of petroleum employes is the Oil Workers International Union-CIO, which for several years, and particularly during the past year, has attempted to grow by swallowing smaller unions.

But now, amazingly, through endorsement of the merger with AFL, the oil group is attempting to grow by having itself swallowed by a larger union.

For 18 years there have been spasmodic merger movements in the top echelons of the nation's two great labor organizations. Succeeding dynasties of ambitious leaders have visualized themselves the rulers of a coalition of millions of workers (the approximate number is now 15 million) which through sheer bulk could dominate management-labor relations as never before in world history, and indeed might hope to challenge the supremacy of the established political parties.

Many times the huge unions neared cohesion. They put aside their differences in national political allegiance; they minimized their contrary views concerning crafts versus industrial unionism. But always they were finally held apart by the CIO's horror of disembodiment in the teeming maw of the great AFL.

Leaders confident—Though this problem lingers, both AFL President George Meany and CIO President Walter Reuther believe it can be dissipated. Meany declared in a year-end statement that "prospects toward labor unity in 1955 are brighter than ever before . . . on a completely fair basis that will protect the rights and integrity of all affiliated unions."

Reuther, who stands to be the loser if there is a loser, is plumping no less vigorously for the merger, apparently confident that he can retain his own personal authority and likewise maintain the identity of the 30-odd unions in his 5 million-man organization.

This is not to say that Reuther's benediction is enough to guarantee a workable merger. The CIO is decentralized almost to the point of complete autonomy among the myriads of bargaining units, each jealous of its power of self-direction and suspicious of those charming fellows who toss off airy verbosities from the comfort of their plush offices, far, far from a hard day's work.

Still, Reuther has convinced a sizable portion of his most influential lieutenants. At the 16th annual CIO convention recently in Los Angeles, the merger with AFL was given first place in a list of four top objectives for 1955. (The others: Guaranteed annual wages, lower tariffs, support for foreign aid programs.) Moreover, at a meeting of unification committees in Washington in January, Meany and Reuther gave instructions for specific recommendations on merger problems to be submitted at a meeting in Miami Beach early in February.

Outlook for oil—Meanwhile, somewhere within this vast whirlpool of union scheming is a lesser but no less furious vortex of particular import to oil. An AFL-CIO merger would presumably weld the 90,000-man OWIU to the 91,000-man AFL International Chemical Workers. And, if it hasn't already happened before that time, as it almost assuredly will have, the new combine would likely pluck off the 80,000-man CIO United Gas, Coke and Chemical Workers. The latter union is among those the OWIU has been attempting to swallow for the past year, and matters have now progressed to a stage where only the gulping ceremony remains. This is scheduled to take place in late February at Cleveland, where OWIU and UGCCW will first meet separately and then jointly. The result is held to be a foregone conclusion, although there is a remote possibility that the merger may be frustrated at the last minute. Still standing is an offer by President Dave McDonald of the CIO steel workers to take over the chemical union and hand it a fat organization fund. But McDonald has not pressed the matter, though he dislikes both Meany and Reuther.

Of still additional significance in the projected unification of the three unions is the question of who would head up the 261,000-man combined membership. The CIO coke and chemical workers union contains comparatively few petrochemical workers, hence its dealings with the petroleum industry have been scant. The membership of the AFL International Chemical Workers is approximately descriptive. That leaves the Oil Workers International Union, made up largely of petroleum workers and headed by O. A. (Jack) Knight, himself a former refinery worker, seasoned by years of bargaining with petroleum man-

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agement, a mildly bitter and completely frustrated leader who has succeeded in organizing only one major company in the industry, and a man whose plans for a frontal assault on the industry have long needed only added manpower to be set in motion.

Thus, it is evident that if Knight became overlord of the three unions, the merger would take on greater immediate significance to oil. His ideas are set—the industry cares more for its machines than for its men, he said recently; his strategy has been laid.

Reuther's man—Furthermore, bolstered by his new power and prestige, Knight could be expected to revive promptly his pet "Philadelphia plan" through which he has been trying to capture 800,000 workers in about 20 independent oil and chemical organizations. Thus far none of these has been willing to surrender its autonomy. Under these new circumstances, some might change their minds.

And what would be Knight's chances of becoming leader of the three unions? Very good. Under ordinary conditions the AFL chemical organization might be the dominant partner because it is the larger. But this merger is only a pawn in a larger game. Reuther is not begging his way into this bargain. He is intent on maintaining the identity of his various unions and along with it the power of his sub-chieftains. Moreover, Knight is very definitely Reuther's man. The CIO boss is the strong arm behind the impending merger between OWIU and the chemical workers, which will surely be headed by Knight. The OWIU leader can be expected to emerge as the top petroleum labor leader if and when the CIO and AFL join forces.

Bright Picture For Asphalt

WITH THE PRESIDENT urging a $101 billion expenditure on highways during the next ten years, the asphalt picture is looking up.

Back in 1930, a highway wasn't a superhighway unless it was made from concrete. Then, concrete construction led asphalt types by a three-to-one ratio. Today, new construction of highways finds asphalt way in the lead by a 9-to-1 clip. Of the four big turnpikes—Pennsylvania, New Jersey, Maine and Oklahoma—all are constructed from asphalt except the Pennsylvania one (recently 22 miles of it were resurfaced with asphalt).

The answer lies in the lower initial cost of a flexible or asphalt-type pavement. A big variable is the soil condition; where favorable, it is actually possible to build three miles of flexible pavement as against one mile of the rigid or concrete type for the same price. In other cases the saving is twenty to thirty percent.

As to maintenance, the studies made by The Oklahoma Turnpike Authority preliminary to taking alternate bids on rigid and flexible type pavements showed that the majority of the states had less maintenance costs for asphalt than concrete. Taking all factors into account—age, design and traffic—it is the considered judgment of most unbiased observers that properly constructed pavements of either type have about the same maintenance costs.

Refiners aren't sitting on their hands, either; they're looking more closely at quality. The Asphalt Institute has recently moved its executive offices and laboratories to the campus of the University of Maryland, so that it can expand its research and engineering operations and take full advantage of facilities that are more modern and greatly enlarged. Located near the outskirts of Washington, D. C., it will be more convenient also to the many government agencies and other interested groups in the nation's capital.

Industry In Good Economic Light

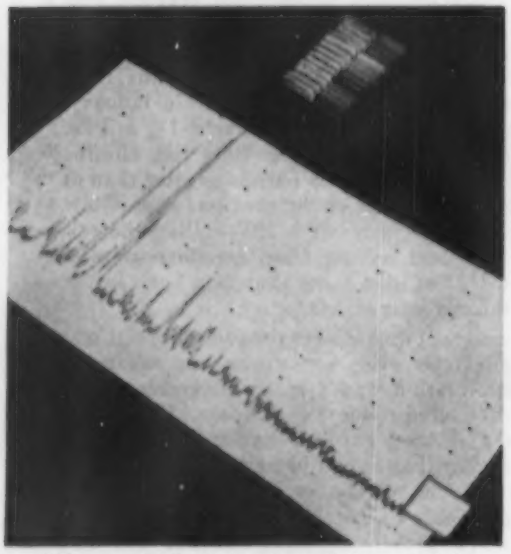
GIANT STRIDES in the elimination of excessive gasoline inventories have put the U. S. petroleum industry in its best economic position in more than a year. Industry now has an excellent opportunity to avoid surplus motor fuel supplies that plagued it the past two years.

This improved economic situation can continue if reasonable restraint is exercised by the industry's refiners, producers and importers. No unreasonable reductions in any branch will be necessary to maintain good balance between supplies and demand, now that excessive gasoline has been absorbed.

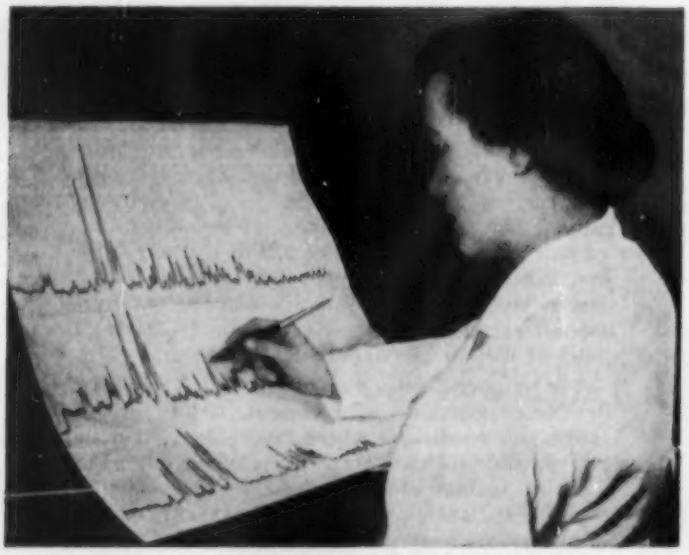
Gasoline inventories in recent months have shown remarkable improvement. In Mid-January, 1955, they totaled 162 million barrels, 1⅛ million barrels less than a year before. Only two months ago stocks were five million barrels greater than at the corresponding time of the previous year, while three months ago they were 10⅛ million barrels higher. As recent as last June, gasoline supplies had totaled 22 million more than had been in the nation's tanks a year earlier.

Previous gasoline excesses proved quite a threat to the industry's price structures, and the relief from this situation was a real achievement, with most of the credit due the refiners. It was accomplished despite gasoline demand being only slightly higher than it had been a year earlier. Reduced crude runs to refinery stills and adjustment of product yields to lower the volume of gasoline output were principally responsible for the progress.

Positioning deposit sample in path of X-ray beam. Crystals of the deposit will diffract the beam, and a characteristic pattern is recorded on the chart at left.



"Fingerprint" of the deposit is recorded on this chart—showing which compounds are present in the deposit sample.



Comparison of sample "fingerprint" with Ethyl's master file of synthesized compounds permits positive identification of chemical compounds present in the sample.

Ethyl Research "fingerprints" engine deposits

Ever since the invention of the internal combustion engine, refiners and automotive engineers have known that under certain conditions engine deposits can create problems.

But to this day, no one is certain which of the many chemical compounds present in the deposits actually cause the trouble.

Ethyl research people have come up with several techniques that promise to give part of the answer.

One of these new techniques—called the "fingerprint" method—works something like this:

A special thermal plug is installed in the engine combustion chamber. Deposits are allowed to build up on the plug, which is held at a controlled temperature. After a certain time, the plug is removed, and the deposits are analyzed.

To identify the compounds present in the deposit, ordinary chemical analysis proved unsatisfactory, so Ethyl people turned to X-ray diffraction. But here again they met a problem. No master identification charts existed for these complex chemicals.

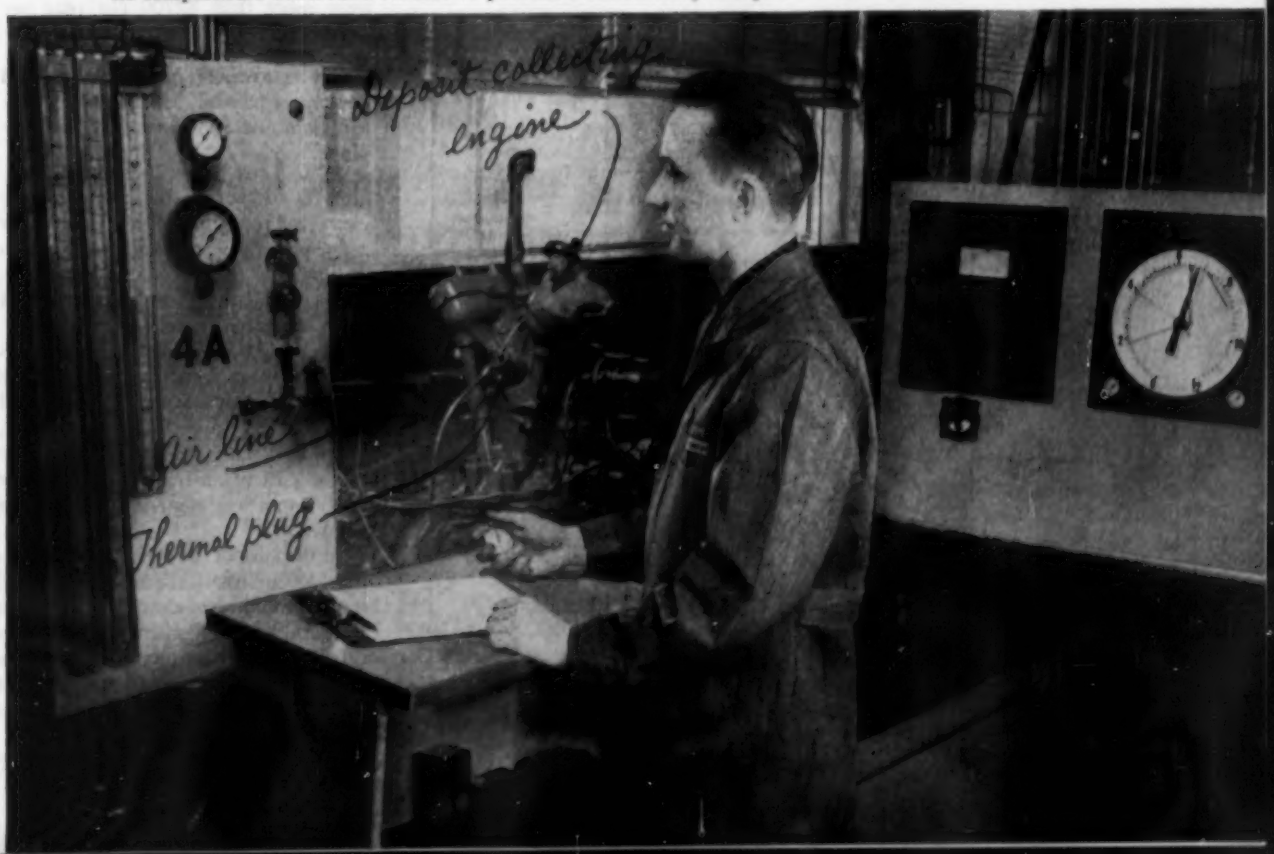
Ethyl synthesized many of the compounds they thought might be in the deposits and made X-ray diffraction "fingerprints" of them. Now, with this unique master identification file, the majority of complex inorganic chemicals present in engine deposits have been identified.

With this basic research tool, Ethyl people are studying the mechanism of deposit formation and gaining new understanding, which will lead to more effective scavenging of engine deposits in the future.

ETHYL CORPORATION
Research Laboratories

1600 West Eight Mile Road, Ferndale 20, Michigan
2600 Cajon Road, San Bernardino, California

Thermal plug in place in single-cylinder research engine. After a certain period enough deposit builds up on its temperature-controlled surface to provide a satisfactory sample.



Fringe Benefits Can Break You!

Fringe benefits cost you $1178 per year per employe. Are you sure you're getting your money's worth?

Lee Laird,
Standard Oil Company of California,
San Francisco

FRINGE BENEFITS cost you an average of $1178 per year per employe. Are you getting your money's worth?

Oil has long been a leader in providing these benefits. Some companies established pension plans as early as 1903, and regular vacation, sick pay and life insurance plans only a few years later. The industry has seen fringe benefit costs rise from an average of 18.7 percent of payroll in 1947 to 28 percent in 1953.

What are fringe benefits?—The term fringe benefits includes legally required payments such as Old-Age and Survivors Insurance, Unemployment Compensation and Workmen's Compensation; also, pensions and other agreed-upon payments such as life insurance premiums, sickness, accident, and medical-care insurance premiums, hospital insurance, severance allowances, employe discounts, miscellaneous payments such as free meals, voluntary payments of various kinds to needy employes, savings and stock purchase plans; paid rest periods, lunch periods, washup time; payments for times not worked such as vacations, employer's share of paid holidays, paid sick leave, paid leaves of absence for civic duties, and military leaves.

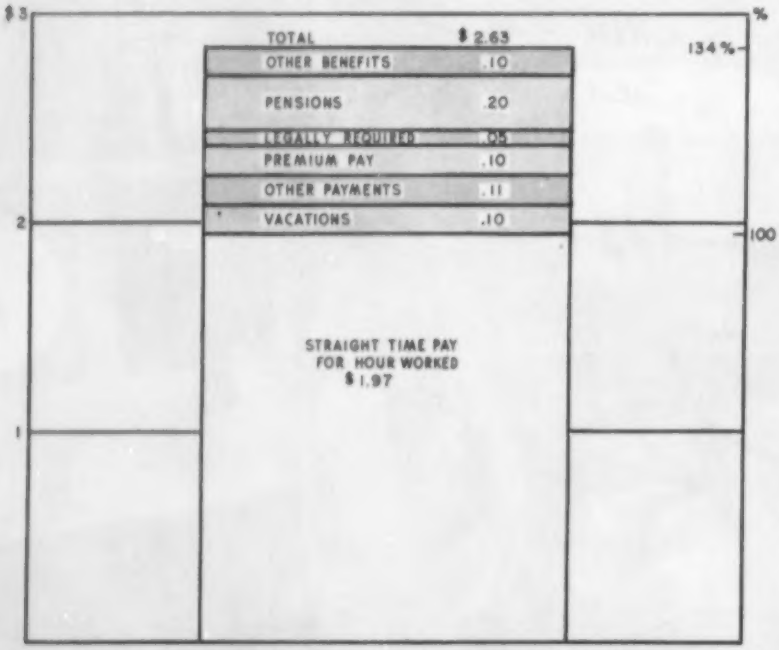


Figure 1. What Does An Hour's Work Cost in the Petroleum Industry? (Based on a survey by the U. S. Chamber of Commerce.)

How do the costs compare?—As compared with oil's outlay of $1178 per year per employe for fringe benefits, the textile products and apparel industry, which has the lowest fringe benefit costs dollarwise, averages $451 per year per employe.

The U. S. Chamber of Commerce made the following findings in a recent study:

- Fringe payments varied widely among the 594 reporting manufacturing companies, ranging from less than 6 percent to more than 55 percent of payroll. (This last was a petroleum company whose payments were more than $2700 per year per employe.)

- The average payment was 16.8 percent of payroll, 31.5 cents per payroll hour, or $667 per year per employe.

- By industries, the average payment ranged from 14.3 percent for pulp, paper, lumber and furniture to 24.5 percent for petroleum companies. Two petroleum companies reported costs of more than 40 percent.

These figures indicate the importance of fringe benefits. They are an important part of your payroll and should be recognized as such. In fact, the wage rate is no longer a measure of the cost of an hour of work. One very important item is for time not worked.

In the case of the writer's own company, benefits included as payroll items amount to almost one-half of the total benefits expense. This brings up a major point, namely, that the percentages cited above do not reflect the true burden of fringe benefits

based on hours actually worked.

What does an hour of work actually cost?—Based on the U. S. Chamber report, it is possible to estimate what an hour of work actually costs. Say your hourly rate is $1.97 and your employe or fringe benefits are the average for the petroleum industry. From Figure 1 it may be seen that the total is $2.63 for that hour of actual work. That is slightly more than one-third more than the $1.97 hourly rate.

What is the trend in fringe benefits costs?—

The September-October, 1954, issue of the *Harvard Business Review* reports results of its survey on fringe benefits in the article "Big Costs of Little Fringes." Some of its highlights are as follows:

"Of the 400 hand-picked companies questioned, only 162 were able to provide sufficiently detailed answers to the 31 basic questions to warrant inclusion in the over-all statistical analysis."

"The crux of the accounting problem facing most of these managements is the fact that very few companies maintain a breakdown by component employe groups showing the cents-per-hour relationship between fringe costs and actual productive hours worked."

"The two main factual findings derived from our survey are:

"The total cost of fringe payments per productive hour worked had reached 40.99 cents by the beginning of 1953.

"Undoubtedly, during the 18 months which have intervened since the commencement of our study, the figure has increased further. This is corroborated not only by outside evidence, such as the terms of new labor contracts signed, but also by the tabulations of several respondents who were able to supply full 1953 figures. Our best guess would be that another 2 or 3 cents has been added in this time.

"This 40.99 cents figure, corresponding to 25.36 cents in 1948, represents a rise of more than 60% during the five-year period 1948-1952."

The above article quotes an execu-

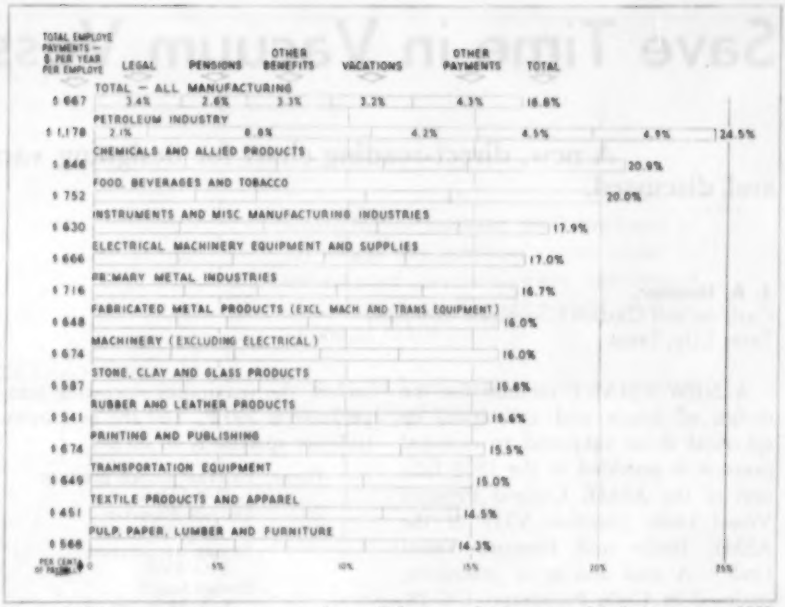


Figure 2. Fringe payments as percent of payroll by type of payment and industry groups, 1953.

tive warning that "one great danger about fringe benefits—as far as management is concerned—is that a considerable number of them have been adopted through expediency rather than on a basis of cool appraisal."*

The above indicates how these fringe benefits have been increasing fairly rapidly for the last several years. Pressures are present for further increases. The unions are currently demanding among other things that employers set up medical and hospital plans, further insisting that the employer pay the entire cost not only for the employe but for the employe's family as well.

Should Employer Bear Whole Load?—This demand poses some serious questions. Employers over the past 15 years have greatly increased the number of their employe benefit plans, as well as the generosity of plans which they already had. Whether this has been done through collective bargaining pressures or voluntarily is not important. But what is important is the already high cost of employe benefits and the still heavy demands for more of them.

The first question is: How much in the way of benefit costs can be paid safely out of productive income?

The answer is quite as important to employes as to employers, because employe benefits are no more secure than the employer's capacity to support them.

Some companies with old established plans have set aside funds to meet future liabilities. But many who have recently acquired expensive benefit plans have not been able to do so. They are paying out of current earnings and could be forced to default if earnings fell off appreciably.

Several phases of hospital and medical plan insurance are still in the experimental stage. This includes major medical expense, hospital and medical plan for annuitants and extending the same coverage to dependents as extended to employees. Theoretically, the ideal is complete insurance for all medical, hospital, and surgical care. Many feel this is not practical at a reasonable cost. And, certainly, cost of hospital and medical care has been increasing steadily for the last few years. Some of the items mentioned could double or triple present cost. So, just where is the end?

Another question arises: Should the employer assume any medical and hospital cost for an employe's family? Is this an employer responsibility or does it belong to the man who has a family?

Two years ago the manager of our company's Labor Relations depart-

See FRINGE BENEFITS Page 192

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Save Time in Vacuum Vessel Design

A new, direct-reading chart for designing vacuum vessels is here presented and discussed.

J. A. Hunter,
Carbide and Carbon Chemicals Company,
Texas City, Texas

A NEW CHART method for the design of heads and cylindrical or spherical shells subjected to external pressure is provided in the 1952 Edition of the ASME Unfired Pressure Vessel Code (Section VIII of the ASME Boiler and Pressure Vessel Code). A trial and error procedure, outlined in Code Paragraph UG-28, is required for thickness determinations by this new method. The accompanying chart is developed for 15 psi external pressure and becomes direct-reading by eliminating the Code chart pressure variable. This direct-reading feature eliminates the trial and error solutions on all single-walled vessels that are required to resist the effects of atmospheric pressure loading. The chart can be used for exact thickness determinations of shells and heads, and for nozzle reinforcement calculations which must be made on distillation columns, condensers, vapor lines, etc., in vacuum service. It can also be used to check existing vessels for adequate design or new operating conditions.

The chart is applicable to carbon steels covered by Code Figure UCS-28. Appropriate charts can be constructed easily for other materials and for other frequently-used pressures. The accompanying chart also can be used in accordance with Code Paragraph UG-28(f), which specifies that Code stamped equipment with external working pressures in excess of 12 psi and less than 15 psi shall be designed for 15 psi.

In applying the chart to the design of cylindrical shells, the intersection of any two of the three variables—temperature, D_o/t ratio, and L/D ratio—determines the third.

For example, find the minimum required shell thickness for a cylindrical vessel to operate under 15 psi external pressure if the outside diameter is 24 inches, the maximum operating temperature is 500 F., and the maximum stiffener spacing is 48 inches.

Given: External design pressure
$P = 15$ psi
Outside diameter
$D_o = 24$ inches
Design temperature
$T = 500$F.,
Design length
$L = 48$ inches.
Required: Shell thickness, t.
Solution: $L/D_o = 48/24 = 2.0$
At the intersection of $L/D_o = 2.0$ and $T = 500$ F., read $D_o/t = 200$; consequently, $t = D_o/200 = 24/200 = 0.120$ inch minimum.

Although the Code chart is based on outside diameters, either the inside or outside diameter can be used to determine the L/D ratio for the accompanying chart. It can be shown that the ratio L/D_i is larger than the ratio L/D_o by a percentage amount equal to $\frac{2}{D_o/t - 2}$. Obviously, as the D_o/t ratio decreases, the percentage difference increases, so that for the smallest D_o/t ratio shown (90) the error is approximately 2 percent. This amount, under the worst conditions, will barely produce readable differences on the scale. In addition, the thickness determined by using L/D_i is on the conservative side, since the ratio L/D_i is always larger than the corresponding ratio L/D_o.

For fixed inside diameter shells, a simple equation solves for the thickness from the D_o/t ratio found from the chart:

$$t = \frac{D_i}{D_o/t - 2}$$

The thickness determined from this equation results in an inside diameter-thickness combination required to produce the ratio D_o/t previously found. Again, there would be a very small error by assuming $D_o/t = D_i/t$ for the ratios involved. This error, however, will result in slightly thinner shells.

The Code example given in Paragraph UA-270(a), will illustrate the solution for fixed inside diameter shells.

Given: External design pressure
$P = 15$ psi,
Inside diameter
$D_i = 168$ inches,
Design temperature
$T = 750$ F.,
Design Length $L = 39$ inches.
Required: Shell thickness, t.
Solution: $L/D_i = 39/168 = 0.232$
At the intersection of $L/D = 0.232$ and $T = 750$ F., read $D_o/t = 395$.

$$\text{Then } t = \frac{D_i}{D_o/t - 2} = \frac{168}{395 - 2} = 0.427 \text{ inch.}$$

For comparison, considering $D_i/t = D_o/t$, the thickness required becomes: $t = D_o/395 = D_i/395 = 168/395 = 0.425$ inch. The error of 0.002 inch is well within the accuracy of the chart readings and for all practical purposes is negligible.

For heads, the intersection of the temperature line and the sphere line determines the $L_i/100t_h$ ratio. For heads with fixed inside diameters, thickness equations, similar to the ones used for shells, apply. The equations are given here for comparison only, since the difference in thickness, as before, is negligible.

For ellipsoidal heads:

$$t_h = \frac{K_1 D_i}{100(L_i/100t_h) - 2K_1}$$

For hemispherical and torispherical heads:

$$t_h = \frac{L_i}{100(L_i/100t_h) - 2}$$

The following problem, given in Paragraph UA-276(a), illustrates a head design. What is the minimum thickness of an ellipsoidal head to be attached to the shell considered in the preceding example, if the inside diameter is 168 inches and the $D_i/2h$ ratio is 2.0?

Given:
External design pressure $P = 15$ psi,
Inside diameter $D_i = 168$ inches,
$D_i/2h$ ratio $= 2.0$
Design temperature $T = 750$ F.
Required: Head thickness, t_h.

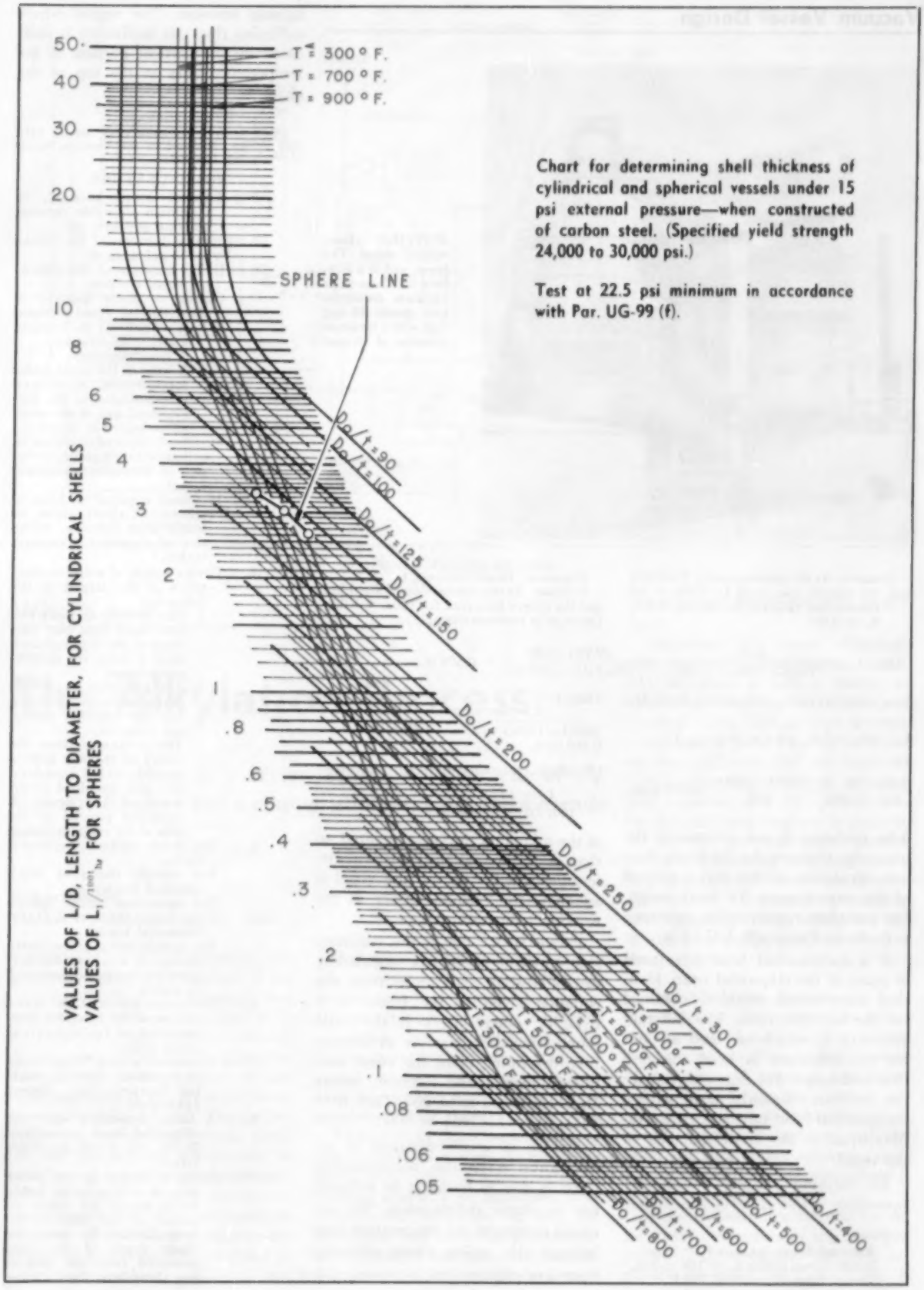
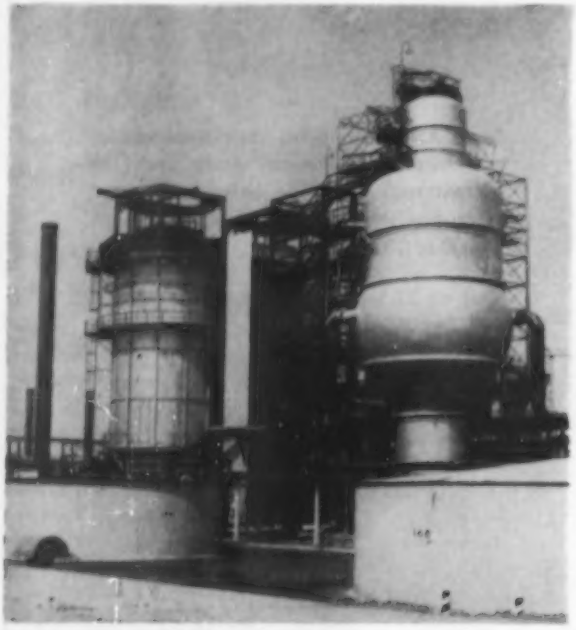


Chart for determining shell thickness of cylindrical and spherical vessels under 15 psi external pressure—when constructed of carbon steel. (Specified yield strength 24,000 to 30,000 psi.)

Test at 22.5 psi minimum in accordance with Par. UG-99 (f).



A typical refinery vacuum vessel. This tower, part of a Richfield Oil Corporation vacuum distillation unit, stands 88 feet high with a maximum diameter of 30 feet.

Given:

External design pressure P = 15 psi,
Inside crown radius L_i = 168 inches,
Design temperature T = 750 F.

Required: Head thickness, t_h.

Solution: At the intersection of T=750 F and the sphere line, read $L_i/100t_h = 3.0$. From table UG-37, for $D_i/2h = 2.0$, $K_1 = 0.90$

$$\text{Then } t_h = \frac{K_1 D_i}{100(L_i/100t_h) - 2K_1} = \frac{(0.90)\ (168)}{100(3.0) - 2(0.90)} = 0.508 \text{ in.}$$

For comparison, assuming $D_o = D_i$:

$L_i/100t_h = 3.0$, then $t_h = \frac{L_i}{100(3.0)} = \frac{K_1 D_o}{300} = \frac{K_1 D_i}{300} = \frac{(0.90)\ (168)}{300} = 0.505$ inch.

This thickness is not necessarily the minimum thickness for the head, since this calculation satisfies only a portion of the requirements for head design. For complete requirements, reference is made to Paragraph UG-33(a).

If a torispherical head were used in place of the ellipsoidal head, identical chart values would be obtained for the $L_i/100t_h$ ratio. The different values of L_i which are used account for the difference in head thickness that is obtained. For example: replace the previous ellipsoidal head with a torispherical head having a crown radius equal to the inside diameter of the vessel.

In checking existing vessels, the procedure is the same. A comparison

Required: Head thickness, t_h.

Solution: At the intersection of T=750 F and the sphere line, read $L_i/100t_h = 3.0$ (same as in previous example).

Then $t_h = \frac{L_i}{100(L_i/100t_h) - 2} = \frac{168}{100(3.0) - 2} = 0.566$ inch.

Of course, assuming $L_i = L_i$, then $t_h = \frac{L_i}{100(3.0)} = \frac{168}{100(3.0)} = 0.560$ in.

of the minimum thickness required, to that of the actual thickness will determine whether or not the vessel is adequate for vacuum service at the working temperature.

Factor B, for use in the stiffening ring moment of inertia calculation, can be readily determined from the equation given in the Code: $B = P(D_o/t)$, where D_o/t is the ratio found from the chart. As an illustration, determine B for the vessel considered in the first example, where D_o/t was found to be 200. Then $B = P(D_o/t) = 15(200) = 3000$.

Failure of vessels designed in accordance with the accompanying chart is due to buckling or collapse, not to plastic deformation. The inclined portion of the temperature lines indicate the region where stiffening rings are effective in increasing collapsing pressure. The region where stiffening rings are ineffective is indicated by the vertical portion of the temperature lines at the top of the chart.

BIBLIOGRAPHY

ASME Boiler Construction Code, Section VIII, 1952 Edition. Published by the American Society of Mechanical Engineers.

NOMENCLATURE

P = External design pressure, or maximum allowable external working pressure, psi.

D_o = Outside diameter of the following vessel sections:

D_i = Inside diameter of the following vessel sections:

D = Outside or inside diameter of the following vessel sections:
1. A cylindrical shell course under consideration;
2. A head skirt; or,
3. A cone at the point under consideration, measured perpendicular to the longitudinal axis of the cone, all measured in inches.

t = Minimum required thickness of cylindrical shell plates, exclusive of corrosion allowance, inches.

t_h = Minimum required thickness of spherical shell plates, or heads after forming, exclusive of corrosion allowance, inches.

L = Design length of vessel section, taken as the largest of the following:
1. The distance between head-bend lines plus one-third of the depth of each head if there are no stiffening rings;
2. The greatest center to center distance between any two adjacent stiffening rings; or,
3. The distance from the center of the first stiffening ring to the head-bend line plus one-third of the depth of the head, all measured parallel to the axis of the vessel in inches.

L_i = The inside radius of spherical shells;
The outside radius of hemispherical heads;
The equivalent outside spherical radius taken as $K_1 D_o$ for ellipsoidal heads;
The outside radius of the crown portion of the head for torispherical heads, all measured in inches.

L_i = The inside radius of the crown portion of the head, for hemispherical or torispherical heads, inches.

T = Maximum design temperature or maximum allowable working temperature, degrees Fahrenheit.

K_1 = A factor depending upon the ellipsoidal head proportions $D_i/2h$, as given in Table UG-37.

$D_i/2h$ = Ratio of major to the minor axis of ellipsoidal heads, which equals the inside diameter of the skirt of the head divided by twice the inside depth of the head measured from the tangent line (head-bend line), inches.

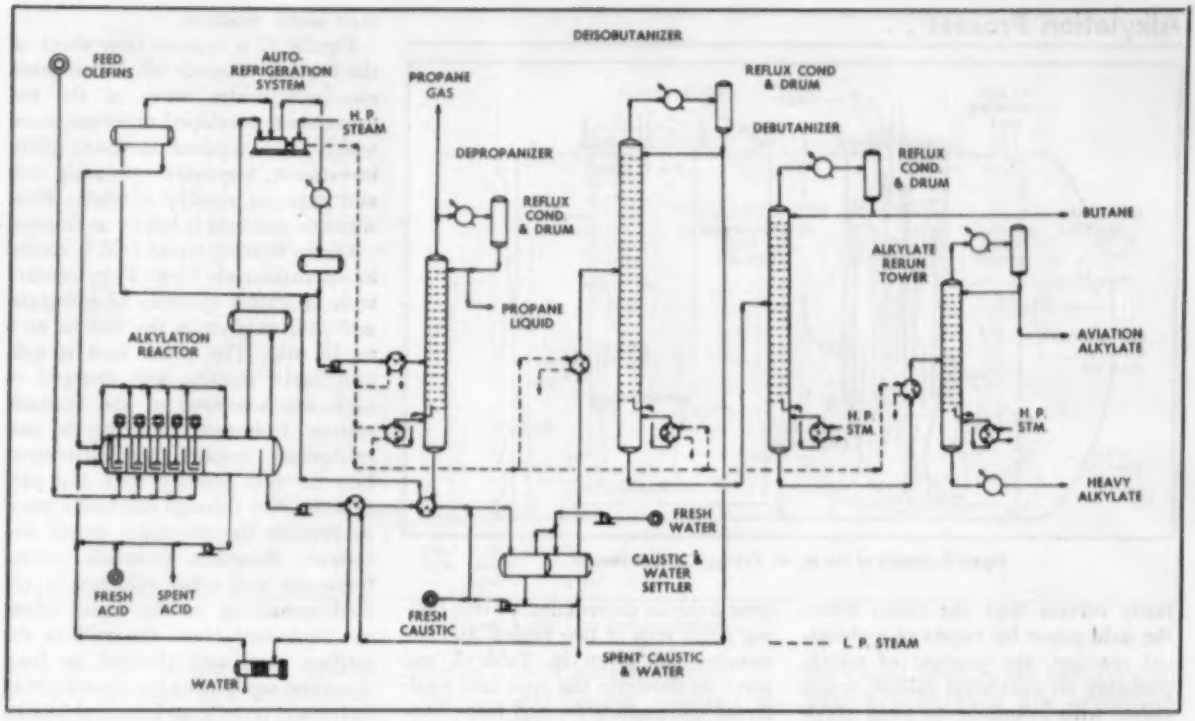


Figure 1. Catalytic Alkylation.

What's new in . . .

The Alkylation Process

Here is a review of the development of the Cascade Reactor and a comparison of the Jet and Cascade systems.

Robert Stiles,
The M. W. Kellogg Company, New York

PRESENT DAY automotive and aviation engines are a product of the cooperative effort of petroleum and automotive engineers. As higher quality fuels are made available through development of processing advances, internal combustion engine designs have improved to obtain more power from each gallon of fuel. The various catalytic processes have made possible the economical production of fuels having a quality rating of better than 90 octane for both automotive and aviation use. These are synthetic mixtures of specialized fractions produced by such catalytic processes as reforming, cracking, alkylation and polymerization. Reforming and cracking operations convert naphthas and gas oil into high octane fractions in the gasoline boiling range, while the alkylation and polymerization processes convert the gaseous or fragmentation products of cracking operations into heavier fractions also in the gasoline boiling range.

High severity cracking and reforming necessary for high octane result in the production of a constantly increasing quantity of isobutane, propylene, and butylenes, so that the alkylation and catalytic polymerization processes are assuming increasing importance as a means for converting these gases into high quality fuels.

Alkylation has many advantages over catalytic polymerization because (1) isobutane as well as olefins are converted, resulting in an increased product yield, (2) alkylate is essentially free of gum forming materials so that additives are not required, (3) alkylate has a higher tetraethyl lead response, and (4) performance in supercharged engines is superior to catalytic polymerization gasoline product. Processing and mechanical improvements of recent years have substantially decreased investment and operating costs which are reflected by a similar reduction in production costs.

The Alkylation Process—In Kellogg Cascade alkylation units isobutane is reacted with olefins to form saturated isoparaffins in the presence of sulfuric acid catalyst. Propylene, butylene, and amylene olefins are converted either individually or in mixtures, and are combined with the isobutane in a highly agitated emulsion in which the continuous phase is sulfuric acid catalyst.

While various authorities differ on the exact mechanism of the reactions involved, the generally accepted sequence is shown in Table 1. It is

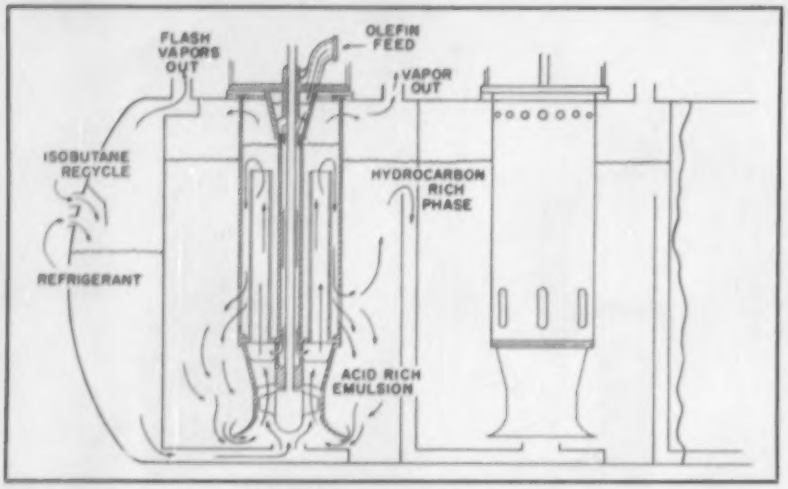


Figure 2. Details of the M. W. Kellogg Cascade reactor.

fairly certain that the olefin enters the acid phase by means of a chemical reaction, the product of which, probably an acid alkyl sulfate, reacts either with isobutane to yield alkylate, predominantly iso-octane; or with another olefin molecule to yield a dialkyl sulfate and polymer which result in the formation of the higher boiling compounds characteristic of heavy alkylate. A highly competitive chemical state exists in the reaction zone. Olefins must first enter the acid catalyst to form acid ester which in turn must react with isobutane before competitive olefin polymerization reactions occur. A high concentration of isobutane must be present and relatively low temperatures (30 to 70 F.) maintained. High temperatures favor the olefin polymerization reactions. Contamination products accumulate in the liquid catalyst and unless held within narrow limits interfere with the desired reaction mechanism.

The simplified description of the reaction mechanism given in Table 1 does not account for all the various resulting isomers, but it will suffice for the present discussion. Component analysis determined by true boiling point tests of two typical alkylate samples are given in Table 2 and serve to illustrate the type and quality of compounds formed from various feed stocks.

TABLE 1
Alkylation Reaction Mechanism

1.	C_4H_8 butylene	+ H_2SO_4 sulfuric acid	$(C_4H_9)HSO_4$ acid butyl ester		
2.	$(C_4H_9)HSO_4$ acid butyl ester	+ C_4H_{10} isobutane	C_8H_{18} iso-octane	H_2SO_4 Sulfuric acid	
3.	$(C_4H_9)HSO_4$ acid butyl sulfate	+ C_4H_8 butylene	$(C_4H_9)_2SO_4$ dibutyl sulfate		
4.	$X(C_4H_9)_2SO_4$		polymer and heavy esters		

Many mechanical and chemical engineering problems are involved in the design and operation of an efficient reactor. Feed and reaction products normally are present in a hydrocarbon liquid phase while the reaction occurs in an acidic liquid phase so that intimate dispersion of these two immiscible liquids is of extreme importance. The reaction is exothermic so that heat must be removed for maintenance of proper operating conditions. Reaction products and diluents in the feed must be removed from the hydrocarbon and acid phases to avoid their accumulation and interference with the isobutane olefin reaction.

Figure 1, a typical flow sheet of the Kellogg Cascade alkylation process, incorporates many of the improvements developed in recent years, which have resulted in lower plant investment, improved operating cost and superior quality alkylate. Flow through this unit is briefly as follows:

Olefin bearing liquid feed is cooled to approximately 35-45 F. by contact with an excess quantity of isobutane and acid catalyst in the reactor at 5 to 15 psig. The olefin feed is split into equal streams and charged to each reaction zone of the Cascade system. Isobutane rich recycle and refrigerant streams are introduced into the first reaction zone and pass in series flow through successive zones to provide the necessary excess isobutane. Reaction products, excess isobutane and other diluents in the feed remaining in the liquid phase are separated from the acid in the settling zone and charged to fractionation equipment for separation of isobutane recycle and normal butane from the alkylate product. The heavy polymers produced are separated from the desirable alkylate in the rerun tower. Isobutane is returned to the head reaction zone of the reactor, and normal butane withdrawn to product storage. Refrigerant vapor resulting from removal of heat of reaction is compressed, condensed and the liquid returned to the head reaction zone. This refrigerant is predominantly isobutane; however, its propane content is higher than elsewhere in the process. A portion of this refrigerant is diverted to the depropanizer tower for removal of propane from the system.

Sulfuric acid catalyst is recircu-

TABLE 2
Componential Breakdowns of Total Alkylates

Types of Alkylate Produced			25% C_3-, 75% C_4-	3.5% C_3-, 90% C_4-, 6.5% C_5-
Components	Boiling Point °F.	F-4 Index No. (4.0 cc TEL)	LV%	LV%
2,3 dimethyl butane	128	205	5.9	4.2
2,2 dimethyl pentane	175	143	4.3	3.3
2,4 dimethyl pentane	177	83		
3,3 / 2,3 dimethyl pentane	194	140	9.5	2.2
2,2,4 trimethyl pentane	211	154	31.9	20.4
Dimethyl hexane	233	44	1.1	5.9
2,3,3 trimethyl pentane	230	225	32.4	37.7
2,3,4 trimethyl pentane	236	193		
Isononanes	265-290	....	3.2	5.2
Isodecanes and heavier	295	....	11.7	11.1
	....	....	100.0	100.0

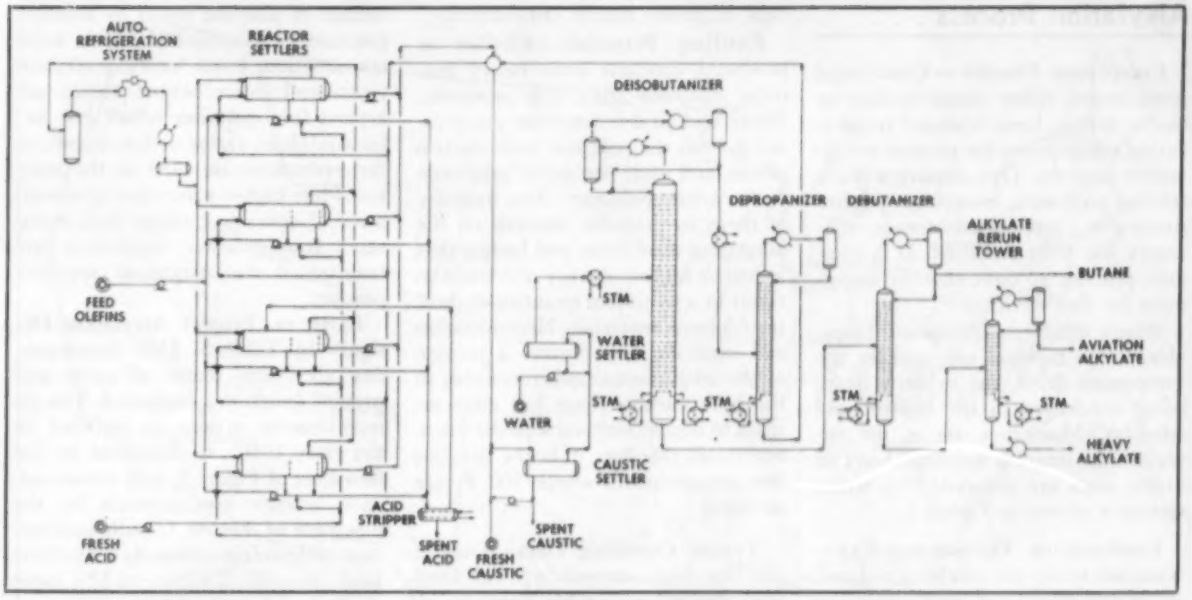


Figure 3. Jet-Type reactor system.

lated through the reactor to stabilize the acid strength and as contaminants build up a portion of the circulating acid is withdrawn and replaced by high purity sulfuric acid.

Acidic material entrained in the effluent hydrocarbons is removed by caustic and water treatment.

Cascade Reactor Design—The Kellogg Cascade reactor, Figure 2, incorporates several features for creating and maintaining proper processing conditions for economic production of high quality alkylate, viz: (1) The internal mixer and the undershot or "L" baffle between compartments, which maintain proper fluid flow conditions for efficient olefin and isobutane contact with the sulfuric acid catalyst for maximum yield of alkylate and minimizing undesirable by-products. (2) Heat exchange surface and auxiliary refrigerants are not required since the heat of reaction is removed by auto-refrigeration in vaporizing a portion of the hydrocarbon stream at the location of reaction, thus promoting isothermal operation. (3) Series flow of isobutane recycle and acid catalyst, and parallel flow of olefin feed create optimum reaction conditions of high isobutane concentration and high isobutane-olefin ratio, with a minimum flow of external isobutane recycle. (4) Multi-contactors with settling zones incorporated in the same vessel reduce the quantity of steel, etc., required and result in a lower installation cost.

Sulfuric acid catalyst consisting of recycle and fresh sulfuric acid, isobutane recycle from the isobutane tower, and liquid refrigerant from the compressor system enter the initial compartment of the reactor where water contained in the recycle stream is removed and the streams chilled to operating conditions. The isobutane and acid liquids flow under the "L" baffle to the intake of the internal mixer where they meet a large circulating mass of isobutane-acid emulsion. In the mixer incoming acid, hydrocarbons and circulating emulsion are pumped past the olefin feed distributors, through reaction tubes, vapor disengaging zone, liquid settling zone and back to the intake of the mixer. Driver capacity requirement is minimized since the pressure drop associated with heat exchange through shell and tube or similar units is absent with auto-refrigeration.

Isobutane dispersion in small droplets throughout the continuous acid phase is essential. The olefins must be introduced with mixing to convert the olefins and isobutane to alkylate. Before returning to the emulsion pump inlet a portion of the hydrocarbon phase equal to the incoming feed streams passes to the next reaction stage. Liquid hydrocarbon containing the excess unreacted isobutane products and the net forward flow of acid catalyst pass over the weir and are diverted to the inlet of the second mixer by the baffle design. Vapors generated are withdrawn from the top of the reactor zone through a control valve and pass to the refrigeration compressor. A pressure differential is maintained between reaction zones to supply sufficient head differential for the light hydrocarbon phase (0.7 specific gravity) to flow into the heavier emulsion (1.3 specific gravity).

Series flow of all isobutane refrigerant and recycle material through the cascade reactor results in a higher concentration of isobutane for a given isobutane recycle flow quantity than would be possible with other flow arrangements. Isobutane available in the liquid refrigerant for vaporization in later reaction zones is present in the liquid phase of earlier zones to increase the isobutane concentration so that better alkylate quality results at lower isobutane concentrations in the liquid products leaving the reactor. Parallel flow of olefin to the reaction zones increases the isobutane to olefin ratio. The combined effect of these factors result in isobutane to olefin ratios averaging 25/1 when the ratio of isobutane in the liquid isobutane recycle stream to olefin in the gross feed is only 2.8/1. Table 3 illustrates how the isobutane to olefin ratio and isobutane concentration varies throughout a five zone reactor. Less isobutane fractionation capacity is installed than would be required for a single stage reactor.

Alkylation Process . . .

Compressor Circuits — Centrifugal compressors, either steam turbine or motor driven, have replaced reciprocating compressors for present refrigeration systems. They require a much smaller plot area, minimum weather protection, and their stream efficiency has been excellent. It is common practice to omit standby equipment for this service.

Where utility conditions are favorable, steam turbines are used for the compressor drive, the exhaust steam being condensed in the heaters and reboilers. Maximum use of the energy in the steam is accomplished and utility costs are reduced. This steam system is shown in Figure 1.

Fractionation Equipment—Fractionation tower size has been reduced by improvement in tray designs of recent years, and perforated trays have replaced the cast iron bubble caps in many recent installations.

Fouling Potentials—Alkylate as produced contains some heavy material resulting from side reactions. These undesirable fractions are present in both the acid and hydrocarbon phases and some are acidic and some hydrocarbon polymers. The quantity of these by-products depends on the alkylating conditions, and factors that influence highest quality alkylate also result in a minimum quantity of these troublesome materials. Neutralization and saponification remove a portion of the acidic compounds remaining in the hydrocarbon phase but some remain to decompose and foul the alkylate rerun reboilers if heavy alkylate flow temperatures above 300 F. are attained.

Typical Operating Data—Yield of alkylate from several typical feed streams are compared in Table 4 with respect to isobutane and acid consumption, along with typical octane ratings of alkylate rerun to aviation gasoline specifications. Higher acid consumption, lower aviation alkylate yields and lower octane values are typical for operation where low isobutane/olefin ratios or low isobutane concentrations are used in the reactor, while higher values are representative of operation where high isobutane concentration conditions are maintained for maximum quality product.

Early vs. Present Alkylation Designs—In Table 5, 2500 barrel-per-day alkylation plants of early and present design are compared. The jet type reactor system as installed in the early 1940's is illustrated by the flowsheet of Figure 3, and recent cascade reactor arrangements by the flowsheet of Figure 1; both incorporate auto-refrigeration for reactor heat removal. Considerably more equipment is required for the jet reactor to obtain the same production capacity than is required for the cascade system. Four individual reactors operating in parallel using approximately 12,800 barrels per day of isobutane recycle are required for the older jet type, while a single reactor with five reaction zones using 4500 barrels per day of isobutane recycle suffices for the cascade design. Similarly, the isobutane tower is reduced from 13½ to 7 feet in diameter and all auxiliary equipment such as exchangers, condensers, reboilers, pumps and piping are proportionally smaller. One centrifugal compressor replaces three reciprocating machines with resulting savings in foundations, piping, buildings, etc.

The depropanizer tower of Figure 3 removes propane from the isobutane recycle where the propane content is 3 = 5 percent, instead of from the refrigerant stream for Figure 1, where the propane content is 15 to 20 percent. Charging a more concentrated stream permits reduced tower size with resulting lower expenditure. The capacity of the debutanizer and rerun towers is comparable for the two flow-sheets but equipment size is smaller for newer plants as reflected by advancements in tray design. # #

TABLE 3

Effect of Cascade Reactor on Isobutane Concentration and Isobutane/Olefin Ratio

Reaction Zone No.	REACTION ZONE No. Front End	2	3	4	5	iC^4 in Regular Olefin in Feed
Plant A:						
iC_4 conc (LV%)	77	71	63.3	54.9	44.5	—
iC_4/olefin ratio (Liq)	22.4/1	27.8/1	23.2/1	18.7/1	14.4/1	3.14/1
Plant B:						
iC_4 conc (LV%)	81.7	76.6	70.6	64.2	56.3	—
iC_4/olefin ratio (Liq)	40.3/1	35.6/1	31.2/1	26.5/1	22.1/1	5.3/1
Plant C:						
iC_4 conc (LV%)	80.8	73.6	66.0	58.1	49	—
iC_4/olefin ratio (Liq)	33.5/1	20.1/1	24.4/1	20.7/1	16.9/1	2.83/1

TABLE 4

Typical Alkylation Yield Data

OLEFINE FEED TYPE	Propylene	40% Propylene 60% Butylene	Butylene	Amylene
* Yield (Volume Percent on Olefines)				
—Total Alkylate	178	174	172	160
—Aviation Alkylate (336° F. EP)	150–160	156–162	153–165	140–149
Isobutane Consumption				
(Iso. iC_4/Olef. Olefin (neglect Fractionation loss)	1.275	1.17	1.106	0.965
Acid Consumption (Average)				
Lbs. 98% H_2SO_4/Gal. Total Alkylate	1.8–2.0	1.0–1.3	0.4–0.6	1.0
Aviation Alkylate Quality				
Research Octane No. — Clear	89–92	92–95	94–97	92–93
1.5 cc TEL	100.5–102.5	102.5–104.5	103–105.5	102–103
ASTM Octane No. — Clear	87–90	91–93	92–95	90–92
F-3 or I-C Octane No. 4.6 cc TEL	103–105	105–107	107–109	105–107
F-3 or I-C Performance No. 4.6 cc TEL	110–117	119–124	124–132	116–123
F-4 or 3-C Performance No. 4.6 cc TEL	132–142	*145–153	150–162	140–148

* True Alkylate—Corrected for Components in Feed.

TABLE 5

Comparison of Jet Reactor and Cascade Reactor Systems for 2500-Barrels-per-Day Alkylation Plant

	Fig. 3 Jet Reactor System	Fig. 2 Cascade Reactor System
Reactors	(4) — 10′ 0″ x 45′ 0″ jet type with eight external emulsion pumps	(1) — 10′ 0″ x 70′ 0″ five reaction zones with five internal emulsion circulators.
Refrigeration	(3)—600-horsepower gas engine driven reciprocating compressors. Two machines normally operating.	(1)—1200-horsepower centrifugal compressor steam turbine driven.
Isobutane Recycle	12,800 bpd	4,500 bpd
Isobutane Tower	(1)—13′ 6″ x 114′ 6″	(1)—7′ 0″ x 104′ 0″
Depropanizer Tower	(1)—6′ 0″ x 85′ 0″	(1)—4′ 0″ x 68′ 0″
Debutanizer Tower	(1)— 5′ 0″ x 87′ 0″	(1)—4′ 6″ x 67′ 0″
Rerun Tower	(1)— 5′ 0″ x 49′ 0″	(1)—3′ 0″ x 49′ 0″

Original presentation was at the annual Petroleum Mechanical Engineering Conference, ASME, Los Angeles, September, 1954.

ACKNOWLEDGMENT

The author wishes to express his appreciation to The M. W. KELLOGG COMPANY for permission to present this material.

Location of polyethylene plants, including those planned or under construction. Note their concentration in the Gulf Coast area. *Tabulation shows design capacity, pounds per year.

Polyethylene—Petrochemical Prodigy

Part 1. Market growth and Process development

Part 2. Production capacity, end-uses and trends

Joseph Gordon, Consultant,
New York

THE WAY THAT petrochemicals have mushroomed in the past 15 years has been of such dimensions that it stands out even in the record-making chemical industry. This merger with petroleum has spawned a host of products beginning with a comparative trickle and becoming today's torrential stream from which about 25 percent of all processed chemicals are now derived.

This swift rise of petrochemicals has made it a symbol of economic and technological success, but those in this thriving industry are not disposed to rest on their laurels. With technological change always a factor, they must maintain a constant lookout for developments. Despite the great progress made, there is no guarantee that the over-all growth rate of the past will maintain itself. Indeed in some sectors, and for some petrochemicals, the growth rate has levelled off or slackened.

But slowing down in some areas does not mean that the petrochemical industry is approaching maturity—far from it. Rather it means that future expansion will require more selective, and longer range planning. That such a prospect can be extremely rewarding is emphatically proved in the most fabulous achievement yet in petrochemicals—the plastic, polyethylene.

First discovered by Imperial Chemical Industries in England in 1933, polyethylene (PE) was not made commercially in the U.S. until about 10 years later, to meet urgent needs for radar insulation in World War II. Since then, for 11 successive years, the supply has sometimes approached, but never actually equalled demand.

Polyethylene . . .

Whenever the two producers, E. I. du Pont de Nemours & Company and Union Carbide and Carbon Company boosted the supply, that added supply by encouraging new uses, would only tend to increase demand.

The stage is set for another major episode in this epic boom. This year and next will see at least half a dozen more companies making PE. by early 1956, the total annual capacity will be about 550 million pounds, a boost of some 300 percent over 1953. This new output will almost surely equal demand, and is likely to result in an unprecedented though moderate surplus lasting through much of 1956 and part of 1957.

Predictions on the future of this amazing plastic can hardly be made without finding the basis of its popularity. The question might well be asked: How does it happen that Carbide and DuPont, without knowhow second to none, have been kept so busy and for so long in keeping up with the mounting needs? Two causes immediately come to mind:

1. The complexity of the manufacturing process, calling for the highest commercial pressures (2000 atmospheres) and close temperature control.
2. The outstanding versatility of the plastic itself.

PE is hardly to be regarded as the ideal or miracle plastic that advertising copywriters are pleased to dream up. Though constantly being improved, it has its limitations, and in some respects is surpassed by its most important rivals, polystyrene and polyvinyls.

The uniqueness of PE is the combination of qualities which makes it a superior type of jack-of-all-plastics. Not long ago a plastics expert compiled a list of 23 desirable plastic properties, found that PE had 19 of them, far more than any other. In PE a plastic becomes available which embodies all of these highly useful traits:

- Toughness and flexibility retained even to Arctic temperatures.
- Outstanding dielectric properties, especially at high frequency
- Lowest weight for given volume (floats on water)
- Resistant to effects of moisture, weather, and many chemicals.

Any of these properties is useful; together they provide a broad and sturdy base for the PE growth structure. However, PE has many other built-in assets which contribute in varying degrees to its popularity in almost every industry. For instance, PE is well adapted to the processing or packaging of foods and drugs because it is inert, non-toxic and odorless. A range of grades from waxes and greases to highest quality plastic is available for various purposes, and the plastic is amenable to all sorts of modifications and improvement both by physical and by chemical means.

PE lends itself to high speed fabrication by extrusion, injection molding and other methods. For merchandising purposes the finished products can be attractively designed and readily colored. The toughness and transparency of the film—which needs no plasticizer—adds considerably to its value.

On the economic side, an inseparable part of the plastics picture, PE is competitively priced, and the trend with larger volume and higher efficiency is still downward. Within the past 24 months, the price has been reduced three times. In short, while each kind of plastic has its own particular areas of merit, no other plastic has PE's capacity for doing so many things so well at its price level.

The supply dilemma posed by this versatility has been further compounded by the drastic conditions of the manufacturing process. As with many other petrochemicals, ethylene is the starting point, but unlike any other petrochemicals—or any other chemical products—PE is made at pressures exceeding 2000 atmospheres, the highest for any continuous chemical processing operation. To operate successfully under such a constant battering, while maintaining close temperature control, not only entails special alloy equipment and machinery of special design, but also specialized high-pressure know-how. All this, of course, multiplies the plant cost comparable with other petrochemicals, for PE requires high maintenance cost and elaborate safety measures in addition to the heavy capital investment. Imperial Chemical Industries has estimated that a unit making 17 million pounds per year would cost about $11 million, far higher than the average for petrochemical products.

With due allowance for the technological and financial hurdles, it is entirely possible that Carbide and DuPont could have kept pace with the demand as it developed, had it not been for the unpredictable peak needs of the military. It seemed that whenever supply was about to bridge the gap, up stepped the Pentagon with a sheaf of military orders to be filled on the double. During World War II, the entire output of Carbide's unit at South Charleston, W. Va., and DuPont's unit at Belle, W. Va., went for radar insulation and other military purposes. Shortly after Korea, the military's share had grown and become more diverse, taking about half of an annual output estimated at around 60 million pounds.

All Out For More

The overall effect of steadily rising supply with soaring demand has kept PE scarce for 11 years. However, a balance is about to be realized. Eight new units, two of them Carbide's will have gone on stream between the summer of 1954 and the middle of 1956. The new producers include some well-known names identified with petrochemicals and plastics. They are: Monsanto Chemical Company, Dow Chemical Company, Texas Eastman Company, Spencer Chemical Company, Koppers Company and National Petro-Chemical Corporation. These new producers between them should by late 1956 have a PE capacity of about 200 million pounds per year with a part slated for production early in 1955.

The extra output bringing ample supply will for the first time permit the uninhibited growth of many PE applications. Moreover, this changing supply status along with the entrance of six new producers will enliven not only the PE field specifically, but also the entire plastics industry and petrochemicals.

Mindful of the need for more PE and of the latent challenge to their 1-2 position, the producers of record have prepared for both with a sharply increased output. DuPont, for instance, will before the end of this year have more than doubled the PE capacity of its Sabine River Works at Orange, Texas. Carbide's plans—on a still greater scale—leaves little margin for doubt that it intends to stay Mr. Big in PE for a long time.

The complete program calls for three new units each with a yearly capacity of 60 million pounds, to be operated by another division, Carbide and Carbon Chemicals Company. The first of these, at Texas City, began operation late last year. The second, part of a brand-new plant at Seadrift, Texas, was completed this past summer. Carbide's expansion goal will be realized in full about the middle of 1955, with the first Pacific Coast unit at Torrance, a few miles from Los Angeles. All told, these expansions will boost DuPont's annual capacity to around 100 million pounds, and Carbide's close to 250 million pounds.

These bold counter-measures by the current producers has impressed, but evidently has not deterred, the newcomers from proceeding with their plans for PE making. Having patiently bided their time until market demand prompted the move, and fortified with a license from ICI early in 1953, five of them launched their almost simultaneous opening gambits. Less than a year later, Koppers joined them by deciding to build a PE unit at Port Arthur, Texas. These new units will start producing in capacities that range from 20-66 million pounds a year.

The largest of these, and probably the first to be completed will be installed by Monsanto at Texas City. So sure is Monsanto of establishing itself in PE that even before the ground-breaking the company served notice of a 50 percent boost in capacity in 1957. By then, Monsanto estimates it will have a shade more than 20 percent of the PE market.

Next in terms of proposed output are Spencer Chemical and National Petro-Chemical, neither at present a major factor in plastics. Spencer's plant at Orange, Texas, is slated for a 50 million pounds per year unit, with National's at Tuscola, Ill., slightly less. The remaining new PE plants, designed for a 20-25 million pound yearly output, will be in Texas and operated by such plastics luminaries as Dow at Freeport, Texas, Texas Eastman at Longview, Texas, and Koppers at Port Arthur, Texas.

Besides their mutual interest in PE, all producers—including DuPont and Carbide—license the basic ICI patent, which expires in 1956. All of the new producers, except Monsanto, are buying the complete package, which includes assistance in design, construction, and operation, in return for a reported lump sum payment of $500,000 plus sales royalties.

Polyethylene is molded into a variety of containers. Flexible bottles in standard sizes, range from one-ounce bottle to the 13-gallon carboy.

Lightweight, flexible polyethylene being lowered in a water well. This pipe is especially resistant to the corrosive action of soil.

Growing Pains

To reminiscent old-timers at ICI, this intense flurry of activity must seem like a far cry from PE's modest beginnings in 1933. The first year polymer was made in an autoclave in the course of a research program on high pressures. Commercial progress was slowed for lack of suitable alloys to withstand the massive pressures and for lack of applications. Slowly interest began to pick up as trial evaluations demonstrated its exceptional insulating ability.

In 1937, ICI started making pilot plant quantities, mostly for cable insulation. Two years later it was trying to cope with the need for high-frequency insulation in newly-developed radar. DuPont which was granted an exclusive U. S. license about this time, made further progress and received a Navy contract for PE manufacture shortly after Pearl Harbor.

TABLE 1
Production Capacity for Polyethylene (Resin Grade)

PRODUCER	YEAR-END CAPACITY (Million Lbs./Yr.)		
	1954	1955	1956
Union Carbide	185	250	250
E. I. DuPont	125	125	125
Monsanto	66	66	66
Spencer	....	50	50
National	....	25	45
Dow	....	25	25
Texas Eastman	....	25	25
Koppers	....	25	25
	376	591	611

Meanwhile, the Tonawanda, N. Y., laboratories of Linde Air Products, a Carbide division, had been independently working on high pressure reactions in connection with research on synthetic gems. Ethylene polymers made in Linde's pilot plant were at least equal to DuPont's for high-frequency insulation. Samples submitted to the Navy quickly won Carbide a contract.

Aided by the Navy's highest priorities, DuPont and Carbide rushed their new units at Belle, W. Va., and at South Charleston, W. Va., into production. Despite the staggering difficulties involved in operation, these units were able to meet all military requirements. Carbide's production started in April, 1943 in sufficient quantity and of sufficient quality to meet practically all radar requirements. Coming in a few months later, DuPont's output was diverted mostly to other uses such as communications and a minor amount in film.

The end of hostilities in 1945 enabled the two producers to turn their attention for the first time to what the civilian market needed. They had every reason to expect that polyethylene insulation would do well in peace-time communications and electronics. The very qualities the military prized—low power factor, lightness and water resistance—were also needed for industrial purposes. Continuing military needs and new civilian demands kept the producers operating at capacity after the war.

Aside from this type of demand, the future of PE though promising

Polyethylene . . .

was none too well defined. DuPont and Bakelite as well as some of their customers had been subjecting this new plastic to many application tests and were not unaware of its exciting possibilities. Token progress along new lines was in fact underway prior to V-J day. To cite one case, small PE containers were made as early as 1945, and were highly satisfactory for packaging of corrosive materials, such as for hydrofluoric acid, which dissolves glass. But many a problem had to be solved before the potential would be translated into actual demand. A greater fund of knowledge about PE was needed. Conditions suitable for making the best plastic had to be determined and then worked out in efficient plant operation. Answers still had to be found to knotty problems in processing.

This was the early postwar period when plastics for the first time became generally available to industry and the public. Polystyrene, polyvinyls, and the acrylics had become prominent during the war and were now reasonably abundant. Their military success and the heralded arrival of an "Age of Plastics" helped create a receptive market for these promising new materials. Plastics converters by the dozens rushed in eagerly to meet this opportunity. However, since quite a few were as short on background as they were long in enthusiasm, the all-too-frequent hasty result was an inferior product or a misguided application. The adverse public reaction has ever since been a retardant to plastics growth, though having less effect on PE because of its small and closely monitored supply.

Though many converters became interested in PE because of its intriguing properties most tended to lose interest after considering the obstacles. Other thermoplastics were offering a good future with more immediate possibilities: Supplies were plentiful, they were comparatively easier to process, and prices were lower. The handful of molders and extruders who decided to concentrate on PE were convinced of its merits and eventual success, and reasoned that when the prospects did materialize their position would be enhanced. Until these rewards could be reaped, they were prepared to provide the patience and ingenuity needed.

Processing of PE has bucked up against many problems, some typical of other plastics and others peculiar to itself. In the extrusion of film, build-up of static electric charge caused the film to stick to itself and to the machine. Yet things that were meant to stick to it would not, and that involved additional problems in printing, labeling and sealing. PE molders had to acquire special techniques, like using higher temperatures to get the proper flow characteristics. Mold design and product annealing had to allow for PE's relatively high shrinkage (2-5 percent).

Despite great precaution, sometimes the final product would develop flaws, either because an unsuitable grade had been selected or because of drastic service conditions. For instance, molded PE products in contact with some hydrocarbons might leak or become brittle. Pipe and insulation in outdoor applications sometimes showed fairly rapid deterioration. The remedy came with the use of higher grade plastic, or with the addition of pigments and antioxidants. Such cases were few and far between, but underscored the need for more technical and service data.

One by one the answers to such problems were forthcoming. In making these gains, processors were aided considerably by the two producers and by equipment manufacturers. More often than not, cooperative efforts found the key. However, DuPont and Carbide did not lose sight of their primary objective—a constantly improving product made more efficiently. This was the most direct route for PE to reach the position warranted by its potential. Sparing no tool in their technical arsenals, they intensified their PE investigations using every conceivable approach that appeared likely to shed light on the unsolved problems.

As the name implies, polyethylene is an ethylene polymer made by the apparently simple reaction:

$$n\,CH_2 = CH_2 \rightarrow (C_2H_4)_n$$

Depending on the number of molecules linked together, (MW) the polymer formed actually can be one of a series of grades ranging from liquids and greases through waxes and finally to plastic quality. Though high molecular weight products (30,000-40,000 MW) are generally the best for PE plastics, this is by no means the only criterion. Intensive research has paid off with new data bearing on the relationship of structure and properties.

The plastic quality also is affected by molecular weight uniformity; a narrow range is preferable to a broad one. Experimental X-ray studies reveal that in better plastic grades the polymer chain tends to be linear. More recently, it has been found that branching to a moderate degree can be advantageous by increasing flexibility. Still more recently, DuPont research has found that the length of the branches, and the ratio of the long to short branches play significant parts in plastic properties.

This fact finding has been an integral part of the program for better PE. However, it is quite another matter to operate and control the process to make the desired polymer on a commercial scale. Control of operating conditions in this polymerization is critical. High temperature speeds up the reaction but the product is of low molecular weight and lacks uniformity. Since the polymerization is highly exothermic, close temperature control is a must. Formerly, the difficulty of controlling this heat evolution would mean not only a low quality plastic, but even runaway temperatures and reactions of explosive violence.

The catalyst and the purity of the ethylene feed stock are two other variables that markedly influence the rate of polymerization and product quality. Too little catalyst slows down the reaction; whereas too much leads to an oxygenated polymer which is inferior and more susceptible to deterioration in service. The general idea with regard to the ethylene is the purer, the better; this is especially true if the unconverted ethylene is to be recycled. A purity of 99.8 percent or better is preferable, with a minimum of oxygen and olefinic impurities.

However, of those factors that govern the process efficiency, the most distinctive and hardest to achieve is the extremely high pressure. It is doubly useful, making possible the high molecular weight product desired and speeding up the reaction. Continuing advances in technology have steadily lifted the

ceiling on operating pressures. Today's practice exceeds 30,000 psi, compared with about 10,000 psi before 1940, and the plastic quality reflects this.

But this trend to ever-greater pressure has created problems of the most complex sort, both in design and in fabrication. In recent years, special alloys have been developed to withstand the severity of these conditions. The difficulties have been accentuated because of cooling requirements to maintain the close temperature control. Adequately providing for maintenance and safety have also proved formidable. Perhaps a better inkling of what World War II production was like can be gathered from the fact that a pound of equipment was consumed or scrapped for every six pounds of PE made. The equipment had to be designed for easy maintenance and quick operating changeovers to standby units. Despite the progress made since then, these remain the bugaboos of the PE process.

In attempting to overcome the problems associated with extreme high pressures, DuPont and Carbide were actually further along than they at first expected. Much of the necessary data and technique was already available, needing only to be coordinated and applied. For instance, in Carbide's case, the various divisions of the company possessed many of the answers to particular parts of the problem. Linde had an extensive background in high-pressure gas reactions, dating back to the first commercial separation of ethane in 1918; Electromet division has been a leader in development of special alloys; Carbide and Carbon Chemicals has gained vast experience in all kinds of petrochemical operations.

Similarly, DuPont was able to gather the desired information from its own network of operations. Though each company has evolved somewhat different approaches in PE manufacture, basically they have had to solve the same problems. How each has achieved this purpose is one of the most closely guarded of industrial secrets.

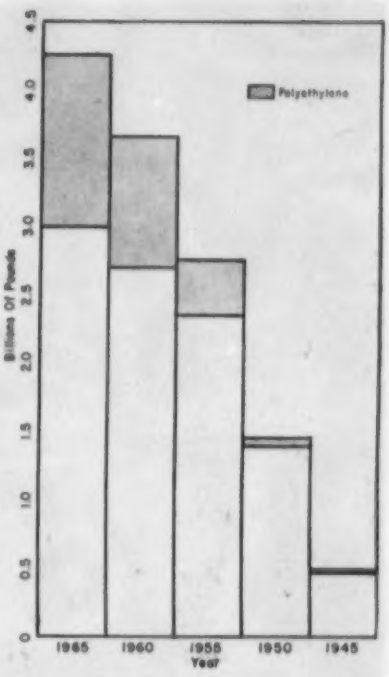
Making Its Way

Application of this technological knowledge kept raising the efficiency of manufacture, helped bring prices down and gave better products for specific uses. The processors in turn were working out the special techniques to get best results. They found that use of higher temperatures made possible faster extrusion and shorter molding time. Better design and control gave improved dimensional tolerance, making possible larger and more intricate parts. By special machine adaptation and by use of thin liquid coating, the static problem with PE was greatly alleviated. Corresponding progress with the film enhanced its uniformity and overcame its reluctance to be imprinted. Suitable adhesives were also found, though electronic heat sealing became the more usual practice.

These were all indispensable preliminaries to mass production and hence to large volume markets. Each success linking to the next, set into motion a favorable development cycle, bringing results in many areas of application. In the period from 1946-1950, insulation continued its steady rise as the chief use, but the newer forms and applications were starting to move up rapidly. PE film in particular began to find by early 1948 wide acceptance in packaging of fresh produce, because of its capacity to transmit oxygen and carbon dioxide while retaining moisture. The upcoming frozen food industry became interested in this moisture retention and its flexibility at low temperatures. Such properties soon brought wide use for PE film, though its progress has been and still is—marked by keen contention with other types including cellophane, vinyls, and others.

Related merits of PE film and sheeting were extended to a wide variety of packaging and shipping needs. Inertness and water resistance fostered its acceptance for drum and carton liners, for food and pharmaceuticals, hygroscopic materials, and corrosive products. Paralleling this has been a growing trend since 1949 of using a PE film or waxes in multiwall paper sacks, a major packaging field.

Containers — Of the many forms that PE assumes, probably the most successful in its field has been the "squeeze" bottle. The development of this new kind of package is credited to a cosmetics chemist of Chicago. In 1947, while hopefully seeking for a squeezable dispenser for a deodorant preparation, he tried out but found



Annual production of ethylene chemicals (1945-1946 estimated).

wanting many possible materials, before encountering PE. Then followed months of work with Plax Corporation of Hartford, Conn., to design and fabricate a suitable container. This container, the familiar PE squeeze bottle, proved to be an immediate merchandising success. In a brief time, the product had become a leader in the cosmetics field, where packaging often plays a dominant part in success. This whirlwind progress induced many others especially in cosmetics and specialty products, to switch over to this new kind of container. It is estimated that 250 million of these bottles will be made in 1954 to package well over 2000 products.

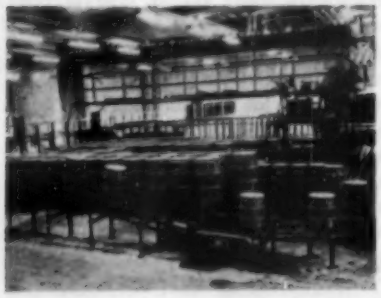
Less publicized but similar in type has been the evolution of larger PE containers for industrial packaging. For the most part, these have been intended to supplement or replace glass in transporting corrosive materials like acids. Step by step, the containers have became larger. Gallon sizes were ready early in 1950, and processors were moving toward a larger goal when a different kind of problem intervened, the invasion of South Korea in June of that year.

##

End Part 1. Part 2 will follow in an early issue.

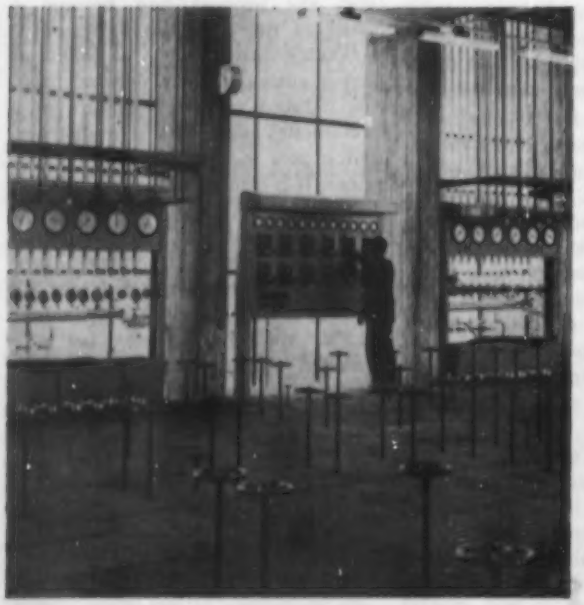
1. Heated underground culvert houses lines leading from base oil storage tanks to lubricant blending and packing plant at Rasta near Stockholm, Sweden. New plant is owned by Swenka Shell.

2. Plant at night reflects extensive use of fluorescent lighting. Built of brick, the building houses some equipment which would be placed outside in U. S. practice.



3. Modern conveying system for filling and loading barrels is located on basement floor of four story building. First and second floors are for blending and storage.

Take a Look at Swedish Design



4. Top floor houses control center. Note projecting valve wheels from lines floors below. Capacity of plant is 20,000 tons per year.

5. Barrels are transported on electrically driven folk-lift trucks to railway cars or trucks. Pictures courtesy of American Swedish News Exchange, Inc.

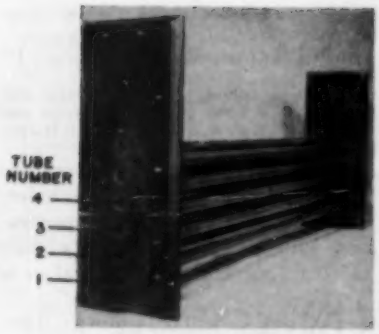


Figure 1. Tube bundle (plain) used in experiments.

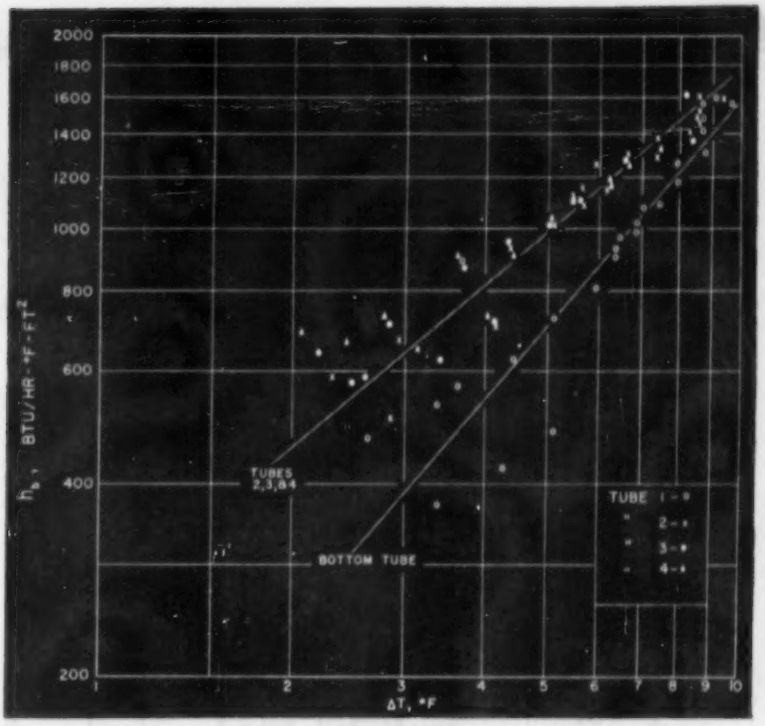


Figure 2. Effect of tube position on boiling coefficient propane at 40 F. outside finned tubes.

Boiling—Outside Finned Tubes

Under certain boiling external conditions the large external heat transfer area provided by finned tubes may be used to definite advantage.

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BOILING HEAT transfer depends upon the properties of the fluid, the temperature difference between the liquid and metallic surface, and the nature of the surface including its shape. Common operations where boiling occurs are reboilers for fractionating columns and evaporators in refrigeration systems. In these services the heat transfer tubes are often horizontal and have the heating fluid inside the tube with boiling outside.

Finned tubes are advantageous when the heat transfer coefficients on the outside of the tube are low relative to the inside so that an increase in outside surface causes a substantial increase in heat transfer. Boiling coefficients are relatively high when high temperature differences (10-20 F.) occur between the surface and the boiling liquid, but may be relatively low at low temperature differences (2-5 F.) especially for organic liquids.

Boiling data have been obtained in pilot units employing commercial tubes three feet long. Figure 1 shows the tube arrangement, with heat transfer taking place in the four lower tubes of the center row.[1,2] Heat was transferred from water inside these tubes to boiling refrigerant outside the tubes. Duplicate tests were run with plain tubes and with integral finned tubes having 19 fins per inch.

Effect of Tube Position—One reason that boiling coefficients increase with increased temperature differences is that more violent agitation tends to increase the boiling coefficient.[3] Thus one would expect the tube next to the bottom would have a higher coefficient than the bottom tube. Figure 2 shows the type of data obtained in which there is a real increase in heat transfer for tubes 2, 3, and 4 at low temperature differences, but at higher temperature differences there is no effect of tube position.[4] Figure 3 gives the finned tube average boiling coefficient curves for tubes 2, 3, and 4 for the five refrigerants tested.

In bundles of practical size, the coefficients for all tubes but the bottom ones would be expected to have substantially the same coefficients.

No generalized correlation is available for predicting boiling film coefficients from the physical properties of the fluids.

Plain vs. Finned Tubes—Figures 4 and 5 show a comparison of the boiling coefficients for propane and dichlorodifluoromethane with plain and finned tubes.† In an earlier experiment, Zieman[5] showed the over-all performance of a clean finned tube to be up to twice that of the corresponding plain tube when boiling isobutane outside with steam condensing inside, Figure 6.

The large external heat transfer area provided by finned tubes may be

* Mr. Myers is at Purdue University, Lafayette, Ind.

† In reference (1), the titles were interchanged on Figures 7 and 9.

Boiling–Outside Finned Tubes . . .

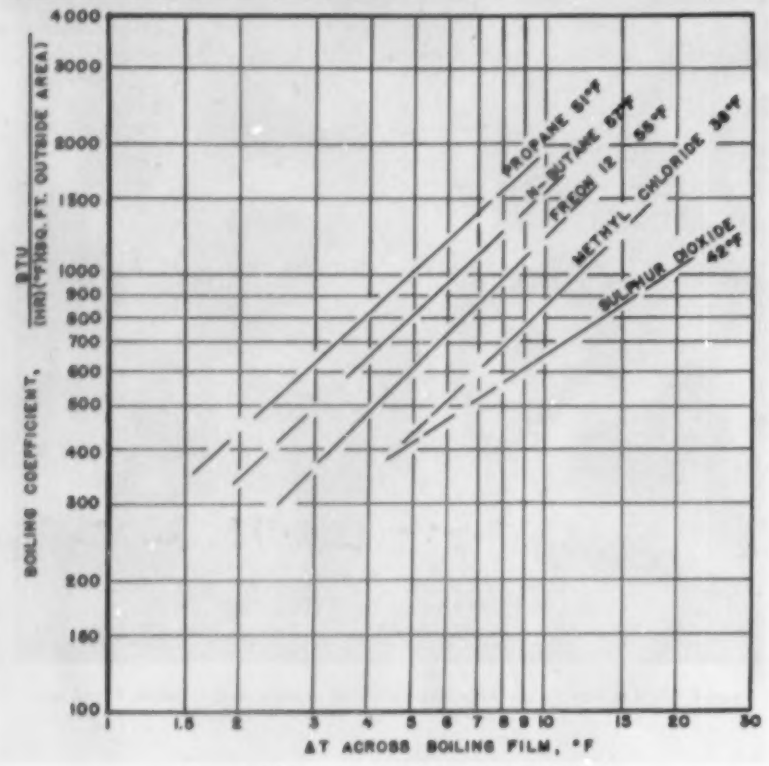

Figure 3. Boiling coefficients for average finned tube.

used to definite advantage under certain boiling conditions. In general it may be stated that if the fin side coefficient is lower than the inside coefficient that the length of finned tube required for a given heat duty requirement is less than the corresponding plain tube required. In boiling applications the fin side boiling coefficient in certain instances may be of the same magnitude as the corresponding plain tube coefficient when the water side temperatures and coefficients are identical. This is due to the fact that the boiling film Δt for the plain tube may be greater than that for the finned tube. Therefore the consideration of finned tubes for boiling applications involves both the $\left(\frac{h_o}{h_i}\right)_{\text{finned tube}}$ ratio and the $\left(\frac{h_o \text{ finned}}{h_o \text{ plain}}\right)$ ratio. Figure 7 was prepared to illustrate this principle. In this figure dichlorodifluoromethane is boiled at 50 F. on the outside of ¾-inch, 19 fins per inch tubes and ¾-inch plain tubes with water flowing through the tubes. The water is cooled 20 F. but at three different temperature levels, 80° to 60°, 100° to 80°, and 120° to 100°, the corresponding over-all (ΔT) log mean are 18.2 F., 39.2 F., and 59.5 F. respectively. Parameters for water velocities of 1 through 10 feet/sec. are also indicated. The ratio of $\left(\frac{U_{Lp}}{U_{Lf}}\right)$ and $\left(\frac{\text{Length of Finned Tube}}{\text{Length of Plain Tube}}\right)$ may be read off directly. The following example indicates the use of Figure 7.

500 tubes ¾"—19 fins/inch, 10 feet long (5000 ft. of tubing)
Tube I.D. = 0.526 inches
4 passes on water side
Inlet water temperature = 80 F.
Exit water temperature = 60 F.
Q = 5,100,000 Btu/hr.
Water velocity = 6.0 ft. sec.
Freon-12 boiling on fin side at 50 F.
Fouling factors = 0.001 each side.[4]
A_o finned tube = 0.496 sq. ft./ft.
$\left(\frac{A_o}{A_i}\right)_{\text{finned tube}}$ = 3.59

From Figure 7, curve for t_w = 70 F. and V = 6 ft. per sec. $\therefore \left(\frac{h_o}{h_i}\right)_{\text{finned}} = 0.40$

$\left(\frac{h_{of}}{h_{op}}\right) = 1.06$ and $\left(\frac{U_{Lp}}{U_{Lf}}\right) = \left(\frac{L_f}{L_p}\right) = 0.705$

The plain tube will require $\left(\frac{1}{0.705}\right) = 1.42$ or 42 percent more tubing than the corresponding finned tube unit, or $\left(\frac{5{,}000}{0.705}\right) =$ 7000 ft. of tubing. The plain tube unit must have a tube pass arrangement and tube length such that $V_{water} = 6.0$ ft./sec. for the comparison.

If the inlet water temperature was raised to 100 F. and the water velocity allowed to drop to 2 feet per second with an exit water temperature of 80 F., the corresponding values of

$\left(\frac{h_o}{h_i}\right)_{\text{finned}} = 1.03$, $\left(\frac{h_{of}}{h_{op}}\right) = 0.905$,

and $\left(\frac{L_f}{L_p}\right) = 0.841$

therefore the plain tube unit will require

$\left(\frac{1}{0.841}\right) = 1.18$ or 18% more tubing.

Design Procedure—To design a shell and tube evaporator for a given application (material, quantity to be evaporated, and pressure), one must have available or specify the following information:

(1) Tube side fluid and its velocity
(2) Inlet and outlet tube side fluid temperature
(3) Fouling factor for tube side fluid
(4) Allowable tube side pressure drop
(5) Tube size and material
(6) Outside fouling factor

To illustrate the procedure, an example calculation is presented.

Example Calculation

Problem: Design plain and finned tube units to cool 500 gallons of water per minute from 80 to 60 F. using boiling dichlorodifluoromethane at 50 F. on the outside of the tubes.

The following items are specified:

(a) Water velocity = 5 ft. per sec.
(b) Tube side pressure drop = 10 psi.
(c) TEMA fouling factors:[5]
outside r_o = 0.001
inside r_i = 0.001
(d) Tubes ¾ inch copper plain and finned (with 19 fins/inch)

Solution:

(1) Heat duty, Q

500 gals/minute × 8.33 × 60 × 20 = 5,000,000 Btu/hr.

(2) Design of Finned Tube evaporator.

Dichlorodifluoromethane boiling film coefficient, h_b. This involves a trial and error computation. Average water side temperature = 70 F. Boiling dichlorodifluoromethane temperature = 50 F. Over-all ΔT = 70—50 = 20 F.

Since the temperature drop across the boiling film is proportional to the resistance, $\Delta t_b = (20)\left(\frac{1}{h_b \quad R_t}\right)$

Tube characteristics

$d_i = 0.526$ inches

$A_o = 0.496$ sq. ft./ft.

$A_o/A_i = 3.59$

$A_{cs} = 0.001505$ sq. ft./tube

$$h_w = (150)\ (1 + 0.011 \times 70)\ \frac{(5)^{0.5}}{(0.526)^{0.5}} = 1093$$

$$\frac{A_o}{A_i\, h_w} = \left(\frac{3.59}{1093}\right) = 0.00328 \frac{\text{hr. °F.} - \text{ft}^2 \text{ outside}}{\text{Btu}}$$

Outside fouling resistance $= 0.001$

Inside fouling resistance $= 0.001$

$$\frac{A_o}{A_i} r_i = (3.59)\ (0.001) = 0.00359$$

Over-all heat transfer coefficient

Assume metal resistance neligible

$$\left(R_t - \frac{1}{h_b}\right) = \frac{A_o}{A_i\, h_w} + \frac{A_o}{A_i} r_i + r_o$$

$= 0.00328 + 0.00359 + 0.001 = 0.00787$

Assume $\Delta t_b = 4.10$ F.

From Figure 5 $h_o = 490$

$$\frac{1}{h_b} = \frac{1}{490} = 0.00204$$

$R_t = 0.00204 + 0.00787 = 0.00991$

$$\text{Calculated } \Delta t_b = \frac{(0.00204)}{(0.00991)}(20) = 4.11 \text{ F.}$$

$\therefore h_b = 490$

$$U_o = \frac{1}{R_t} = \frac{1}{0.00991} = 101 \frac{\text{Btu}}{\text{hr. °F. ft}^2 \text{ outside}}$$

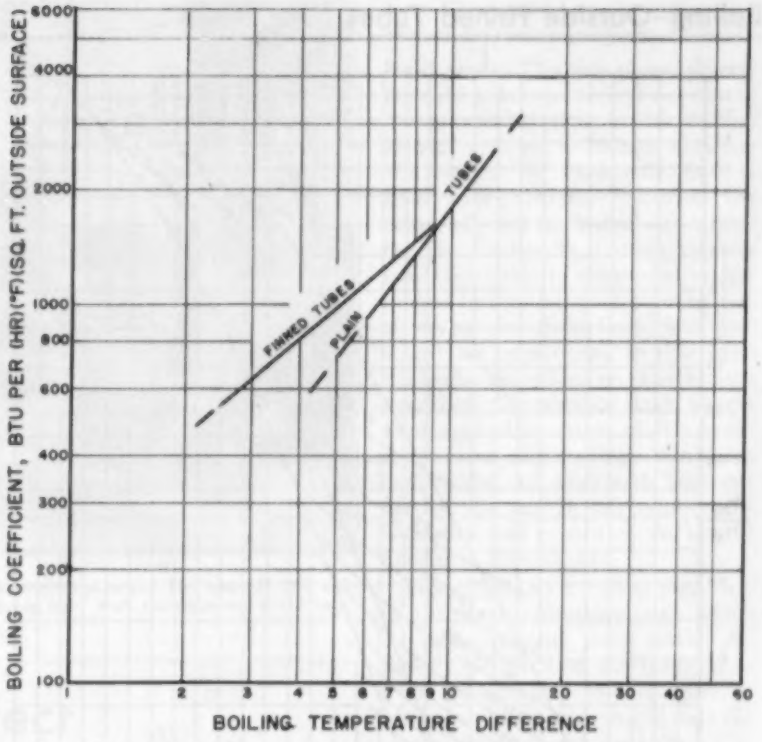

Figure 4. Boiling coefficients for propane (at 40 F., Tubes 2, 3 and 4).

$$\therefore U_L = (101)\ (0.496) = 50.1 \frac{\text{Btu}}{\text{hr. °F. ft of tubing}}$$

to determine the length of tubing required:

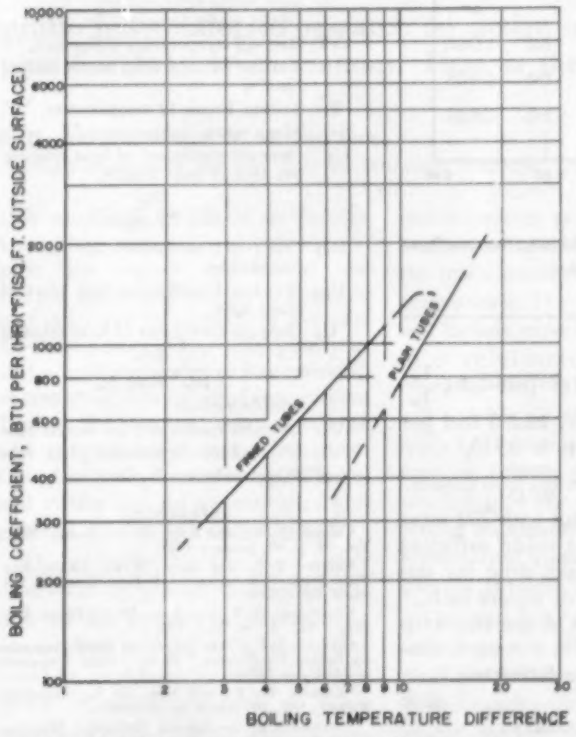

Figure 5. Boiling coefficients for dichlorodifluoromethane (at 55 F., Tubes 2, 3 and 4).

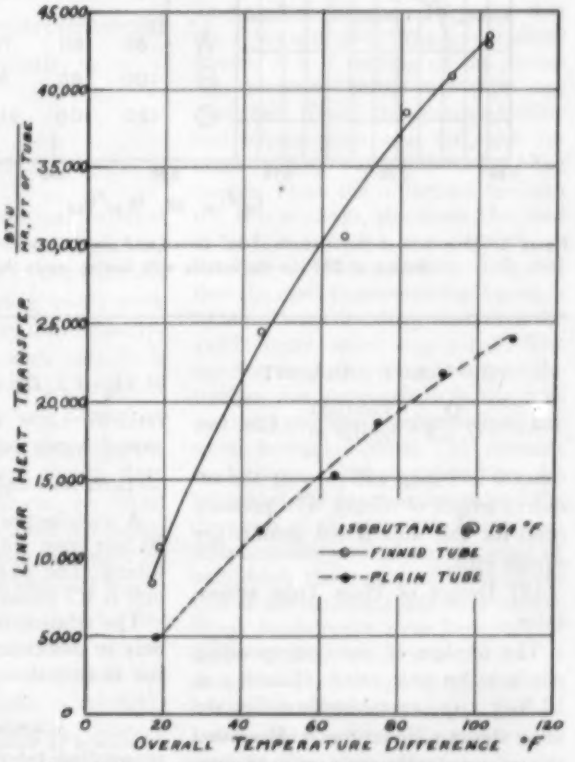

Figure 6. Comparison of finned and plain tubes per unit length.

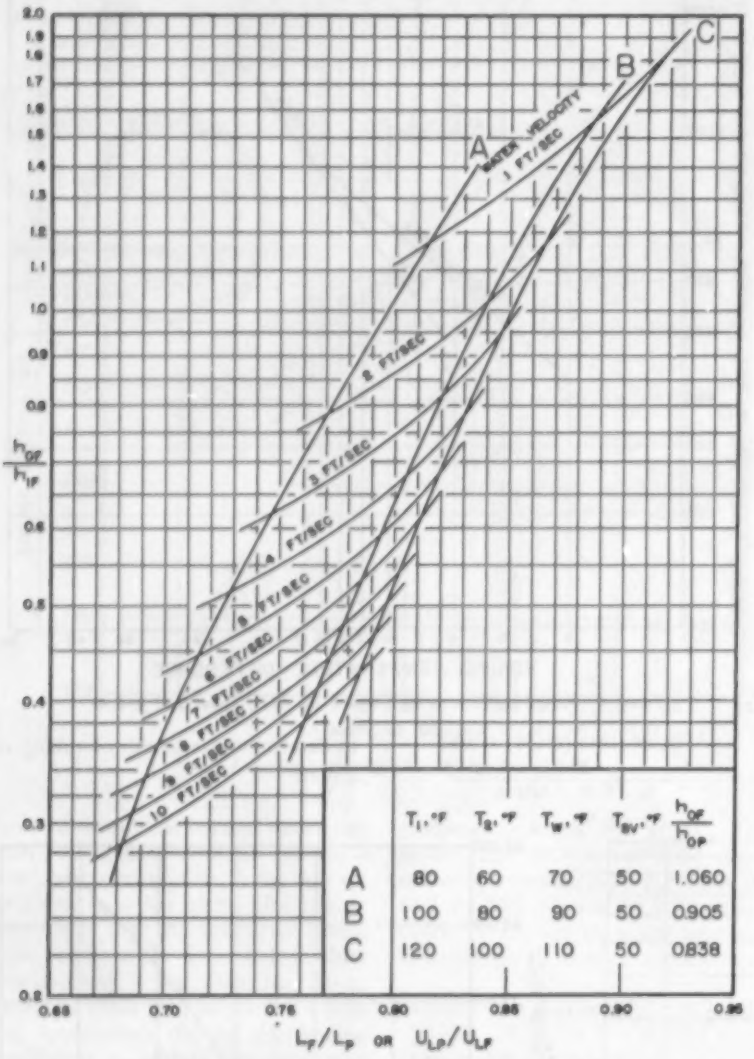

Figure 7. Comparison of performance of ¾" finned and plain tubes with dichlorodifluoromethane boiling at 50 F. on the outside with flowing inside the tubes.

$$Q = U_o A \Delta T = U_L L_t \Delta T$$

$$\therefore L_t = \frac{Q}{U_L \Delta T} = \frac{5{,}000{,}000}{50.1 \times 20} = 4{,}990 \text{ feet}$$

tubes 8 feet long will provide the required length of tubing. The pressure drop for this unit is 6.0 pounds per square inch.

(3) Design of Plain Tube evaporator

The design of the corresponding plain tube unit using ¾ inch o.d. 16-Bwg copper tubing involves the same design procedure. However, since the example problem conditions fit Figure 7, the corresponding $\frac{L_t}{L_p}$ ratio for t_w = 70 F. and 5 feet per second water velocity is 0.715.

$$\therefore L_t \text{ for plain tubing} = \frac{4990}{0.715} = 6{,}980 \text{ ft.}$$

A six-tube pass unit with 702 tubes 10 feet long will provide sufficient tubing. The pressure drop for this unit is 8.7 pounds per square inch.

The relative costs of the two units may be determined in a manner similar to that shown in Reference 7.

#

ACKNOWLEDGMENT

Permission by Wolverine Tube Division of Calumet and Hecla Incorporated to publish this paper is appreciated.

NOMENCLATURE

- A Total outside tube area in evaporator, sq. ft.
- A_{cs} Inside cross sectional flow area of tube, sq. ft.
- A_o Outside tube surface area, sq. ft/ft
- A_o/A_i Ratio of outside to inside surface areas
- d_i Inside tube diameter, inches
- h_b Boiling film coefficient, Btu / hr. ° F. sq. ft.
- h_{if} Inside water-film coefficient for finned tube Btu / hr. ° F. sq. ft.
- h_{of} Boiling film coefficient for finned tube Btu / hr. ° F. sq. ft.
- h_{op} Boiling film coefficient for plain tube Btu / hr. ° F. sq. ft.
- h_w Inside water-film coefficient, Btu / hr. ° F. sq. ft.
- L_f Total finned tube length, ft.
- L_p Total plain tube length, ft.
- L_t Total tube length, ft.
- Q Total heat duty, Btu/hr.
- r_i Inside fouling factor, hr. ° F. sq. ft. / Btu
- r_o Outside fouling factor, hr. ° F. sq. ft. / Btu
- R_t Total resistance to heat transfer, hr. ° F. sq. ft. / Btu
- t_1 Inlet water temperature, ° F.
- t_2 Outlet water temperature, ° F.
- ΔT Over-all temperature difference, °F
- Δt_b Temperature drop across boiling film, ° F.
- T_{sv} Boiling Freon-12 temperature, ° F.
- t_w Mean water temperature °F
- U_L Over-all coefficient of heat transfer per foot of tube length. Btu / hr. ° F. sq. ft.
- U_{Lf} Over-all coefficient per foot of finned tube
- U_{Lp} Over-all coefficient per foot of plain tube
- U_o Over-all coefficient of heat transfer Btu / hr. ° F. sq. ft. outside surface
- U_{of} Over-all coefficient for finned tube
- U_{op} Over-all coefficient for plain tube
- V Water velocity, ft./sec.

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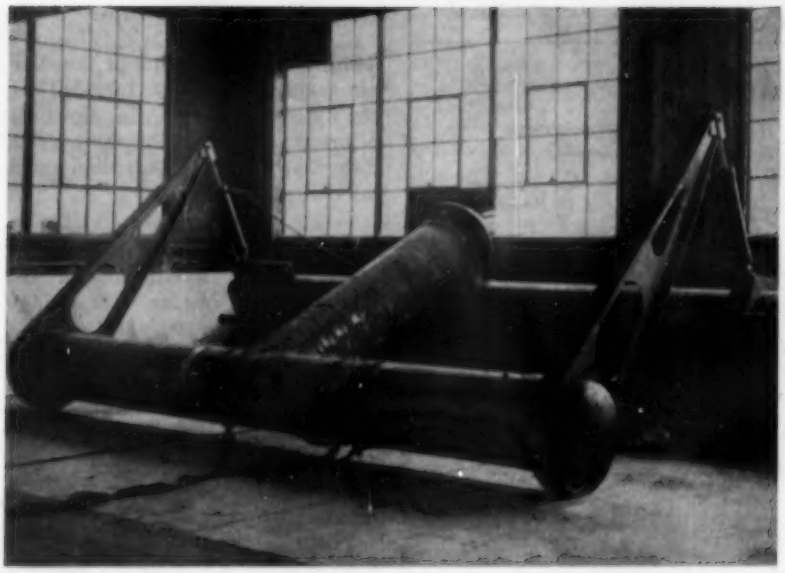

Figure 1. Traverse-bend tests were applied to 24-inch branch connection. Pipe was API 5LX with a minimum yield strength of 52,000 pounds per square inch. Wall thickness was 0.312 inch.

How Stresses Affect Branch Connections

For more than a year Battelle Memorial Institute has conducted research on design of unreinforced pipe line branch connections. Here is the result.

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Applied Mechanics Division, Battelle Memorial Institute, Columbus, Ohio

A RESEARCH PROGRAM to provide basic information on the stresses in pipe line branch connections was started at Battelle Memorial Institute two years ago by a group of five pipe line companies. Over the past year and a half the program has consisted of a study of unreinforced connections. During the current year, the work will be continued under American Gas Association sponsorship. Studies will center around various sizes and types of reinforced connections.

The objective of the past year's work was to provide basic information on the stresses in unreinforced connections of different sizes that could be used later for analysis of the effect of reinforcements. A large amount of data on the stress distribution of unreinforced connections under internal pressure and external loads was collected. These indicated the main weaknesses of unreinforced connections. The coming year's work will include experimental stress analysis of reinforced connections. It is expected that the over-all program will provide an evaluation of various types of reinforcements for different sizes of branches, and design data which a pipe line engineer can use to predict reasonably well the stresses in a reinforced connection in terms of internal pressure and external loads.

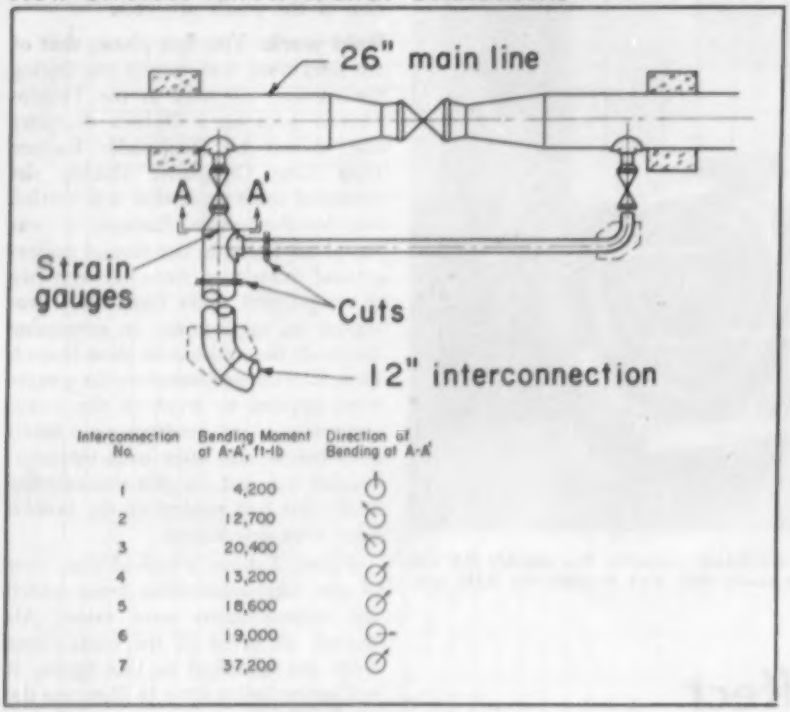
The past year's work may be described in two phases. First, strain-gauge measurements were made on seven branch connections in the field. Second, tests on unreinforced connections were performed in the laboratory. These made up the major portion of the year's program.

Field work. The first phase, that of the field tests, was carried out during the summer of 1952 in the Toledo-Detroit area on a 26-inch diameter line owned by Panhandle Eastern Pipe Line Company. During the course of some work that was carried out by Panhandle Eastern, it was found advisable to cut several underground interconnections between two of its parallel main lines. This presented an opportunity to determine the loads that existed on these branch lines. Electric-resistance strain gauges were applied to seven of the interconnections, and readings were taken both before and after each interconnection was cut. In this manner, the loads that had existed on the branch lines were determined.

Figure 2 shows a typical plan view of the interconnections from which the measurements were taken. Although all seven of the connections were not identical to this figure, it will nevertheless serve to illustrate the results. Strain gauges were applied at Section AA′ after the interconnection had been uncovered. A total of eight strain gauges were used—one every 45 degrees around the circumference of the pipe. These were applied in the longitudinal direction in order that they would measure longitudinal strains. A first reading on the gauges was obtained before the pipe was disturbed. Then, the interconnection and bypass pipes were cut, and another reading was obtained from the gauges. From the difference between the two readings, the stress that had existed in the pipe was determined. Analysis of these stresses indicated that the most prominent loads at each location were bending, and that the axial forces were very small. The bending moments, computed from the stresses, are summarized in the bottom half of Figure 2 for each of the seven interconnections. The moment in foot-pounds that existed on the branch at the gauge locations and the direction of the moments at each interconnection are given. As can be seen, both the magnitude and direction of the bending loads were varied. These loads could have been caused either at the time of construction or as a result of temperature changes, back-fill settlement, etc.

Laboratory work. The major portions of the year's effort was in the

How Stresses Affect Branch Connections . . .



Interconnection No.	Bending Moment at A-A', ft-lb	Direction of Bending at A-A'
1	4,200	
2	12,700	
3	20,400	
4	13,200	
5	18,600	
6	19,000	
7	37,200	

Figure 2. Field measurements.

performing of tests on unreinforced branch connections. Three sizes of unreinforced branches all on 24-inch-diameter pipe were constructed. All of these were subjected to internal pressure and two different bending loads on the branch. Electric-resistance wire strain gauges were used on each connection to determine the stress distributions under the three loading conditions.

Figure 3 summarizes the connection sizes and the tests performed. All three of the connections had 24-inch-diameter headers manufactured to API5LX specifications with a minimum yield strength of 52,000 psi. The wall thickness was 0.312 inch. The branches were 4-inch, Schedule 40 (0.237-inch wall); 12-inch, Schedule 20 (0.250-inch wall); and 24-inch pipe—the same pipe from which the headers were made. The external loads that were applied to the branch during the tests are represented in Figure 3 by F_t and F_v. Application of the load F_v parallel to the axis of the header was called the axial-bend test, and application of the load F_t perpendicular to the axis of the header was called the transverse-bend test. The internal pressure and bend tests were performed on all three connections, and combinations of internal pressure in each one of the bends, applied simultaneously, were performed on the 12-inch connection. Figure 1 shows the 24-inch connection during the transverse-bend test.

Electric-resistance strain gauges were applied to each connection in the shaded quadrants in Figure 3. Rosette-type gauges consisting of three separate elements with their axes 45 degrees apart were used. With this type of strain gauge, it is possible to determine the principal strains and principal stresses at the location of each gauge.

During each test, the strains from each gauge element were recorded at various increments of internal pressure and/or external load. In addition to the strain-gauge data taken during the pressure test, the over-all distortion of each connection when subjected to internal pressure was determined, and some measurements in the change in curvature in the pipe wall at critical locations were made. These curvature measurements were made in order that the strains on the inside of the pipe wall could be estimated.

After all of these tests had been completed, the burst strength of each connection was determined by increasing the internal pressure in each until failure occurred.

Results. The highlights of the data are summarized below. Included are the maximum stresses, the directions of principal stresses, and the over-all distortion of each connection under internal pressure.

In all of the tests, the region of high stress was a very narrow one adjacent to the intersection of the branch and header. These high stresses diminished rapidly within a short distance from the intersection weld, the distance varying from a few inches to about fourteen inches. Consequently, only the stress conditions next to the intersection between the branch and header will be given below.

Figure 4 shows a comparison of maximum stress next to the intersection for the 4-, 12-, and 24-inch branch connections subjected to internal pressure. The abscissa on this plot represents the position around the intersection. The ordinate is a ratio of the maximum principal stress observed to the nominal (Pd/2t) circumferential stress in the header. This method of plotting is used in order to afford a comparison to other plots of the stress conditions under external loads on the branches. In this and subsequent figures, the open circles indicate that the maximum stress was measured on the branch pipe next to the intersection weld, and the black dots indicate that the maximum stress was measured on the header next to the intersection weld. The main points of note in Figure 4 are the magnitude and position of the high stress on the 24-inch connection and the fact that the 12-inch and 4-inch connections' maximum stresses do not vary a great amount from one another.

Figure 5 is a similar plot of the stress conditions next to the intersection weld between the branch and the header during the transverse-bend test. Here also, the ratio of maximum principal stress observed to the nominal stress is plotted on the ordinate. This time, the nominal stress was taken as the highest bending stress calculated from the ordinary beam formula $s = Mc/I$. Here again, it is interesting to note that the 24-inch connection presents the worst case with the maximum stress also occurring at the zero-degree position. The relatively high ratios of maximum to nominal stress under this transverse

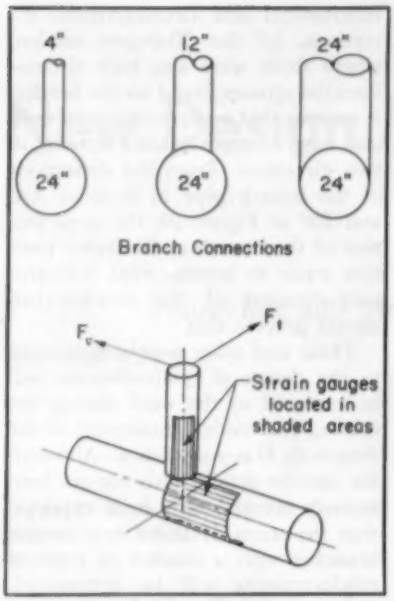


Figure 3. Branch-connection tests.

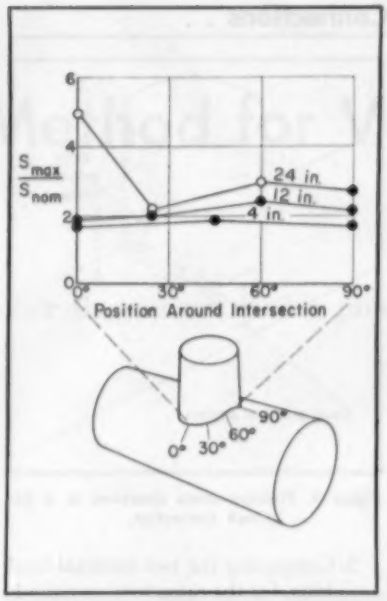


Figure 4. Ratio of maximum to nominal stress in internal-pressure test.

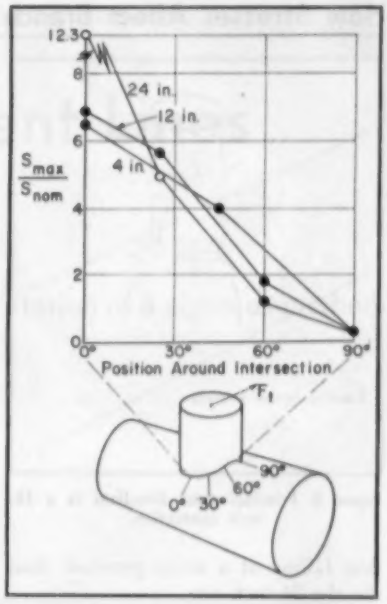


Figure 5. Ratio of maximum to nominal stress in transverse-bend test.

loading are also significant.

Figure 6 is an identical plot for the stress conditions next to the intersection during the axial-bend test. The stresses in all of the connections under this loading are considerably less than in the transverse-bend tests, with the 24-inch connection still exhibiting the worst case.

It might be well to point out a precaution that should be observed in interpreting the data presented as they are in Figures 5 and 6. The ordinates in both figures are ratios of maximum stress to nominal stress in the branch pipe and are, therefore, directly proportional to the section modulus of the branch pipes. Actually, if the same axial or transverse force were applied to all three of the connections, the highest stresses would occur in the 4-inch connection and the lowest in 24-inch connection.

It should also be pointed out that the stress conditions presented in Figures 4, 5, and 6 are valid only up to the point at which the metal around the connection begins to yield.

All of the stresses depicted in Figures 4, 5, and 6 are the maximum principal stresses at the respective positions around the intersection of the branch and header. The directions of these stresses in each branch connection under internal pressure are shown in Figures 7, 8, and 9. It can be seen that, in general, the principal stress directions were parallel to the intersection welds. Note that, in several areas, a pure biaxial stress field exists as indicated by equal principal stresses.

To complete the picture of what occurs in a branch connection under internal pressure, measurements of the over-all distortion of the three connections were taken. Figures 10 and 11 show the relative distortion of various areas of the 24-inch and 12-inch connections, respectively. These schematic drawings are meant to only qualitatively show the amount of distortion.

After all of these tests in which the connections were subjected to internal pressure and external loads on the branch were completed, each of the connections was subjected to a burst test. The pressures at failure were as follows: 4-inch connection, 1970 psi; 12-inch connection, 1580 psi; 24-inch connection, 1620 psi. In the 4-inch and 12-inch connections, the fracture originated in the weld between the branch and header at the 90-degree position. In the 24-inch connection, the exact origin of failure could not be determined, since the fracture traveled adjacent to the weld from the zero-degree position to the 45-degree position before breaking out into the header pipe. Close examination of the fractures did not reveal any reason for the 12-inch connec-

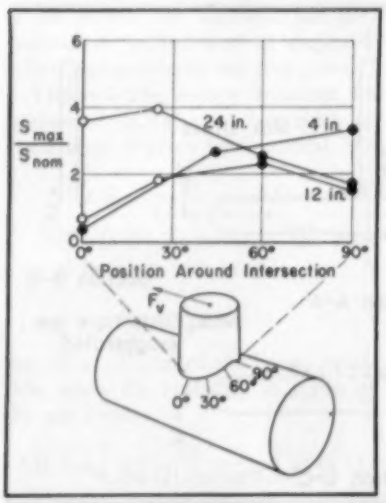


Figure 6. Ratio of maximum to nominal stress in axial-bend test.

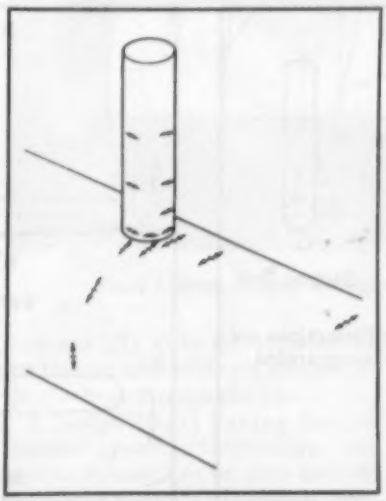


Figure 7. Principal-stress directions in a four-inch connection.

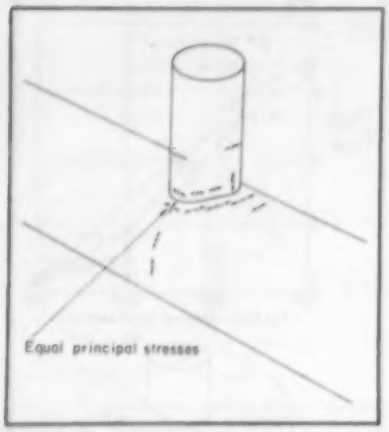


Figure 8. Principal-stress directions in a 12-inch connection.

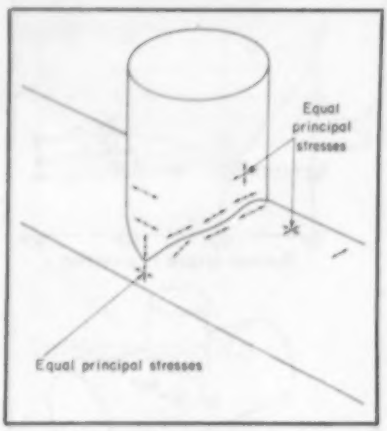


Figure 9. Principal-stress directions in a 24-inch connection.

tion failing at a lower pressure than did the 24-inch one.

The most interesting and important observations that result from consideration of all of the results of the program on unreinforced connections may be summarized as follows:

1. Under internal-pressure loading, for a given pressure, the larger the branch-to-header diameter ratio the higher the maximum stress that was observed.
2. The region of high stress on all of the connections was a very narrow one next to the weld between the branch and header. These high stresses diminished rapidly within a short distance from the weld—in all cases, within one branch diameter of the weld.
3. Comparing the two external-load tests, for the same load in pounds at the end of the branch (approximately the same moment), the transverse bending in the branch produced higher stresses in each connection than did the axial bending.

The results of these data on unreinforced connections provide a basis for attacking the problem of reinforcements. An example of this can be seen by referring to the over-all distortion of the 24-inch connection under internal pressure in Figure 10. Note that the zero-degree section, where the maximum stress was found, tends to "bulge out" in the manner of a bubble. This suggests that if reinforcement of this area is to be effective, the reinforcement must have strength against bending in both the longitudinal and circumferential directions. In the 90-degree section, where there were also high circumferential stresses found on the header, it appears that a reinforcement should also have strength against bending in two directions. From the deflections of the branch pipe in Sections AA' and BB' of Figure 10, the cross section of the branch at 90-degree position tends to become oval. Effective reinforcement of the connection should prevent this.

These and other problems relating to the design of reinforcements will be explored in the work during the coming year under sponsorship of the American Gas Association. Although the specific details have not yet been entirely worked out, it is expected that the stress distribution around branches with a number of types of reinforcements will be determined. This will be done under the same loading conditions and with similar strain-gauge instrumentation as the unreinforced tests. Thus, the stresses for the various reinforced branches can be correlated with stress patterns on the unreinforced counterpart, and the effectiveness of the respective reinforcements related to the branch size can be determined. It is also expected that the data obtained will furnish design criteria from which stresses in a connection can be reasonably well predicted in terms of internal pressure and external loads.

From a presentation at the annual short course in gas technology, Southern Gas Association at Texas College of Arts and Industries, Kingsville, Texas. ##

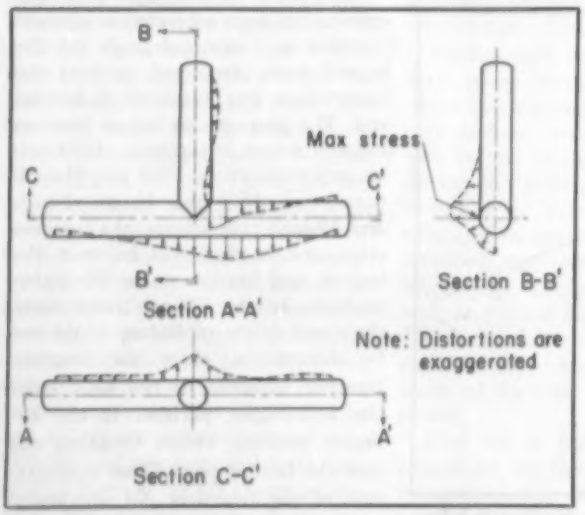


Figure 10. Distortion of 24-inch connection with internal pressure.

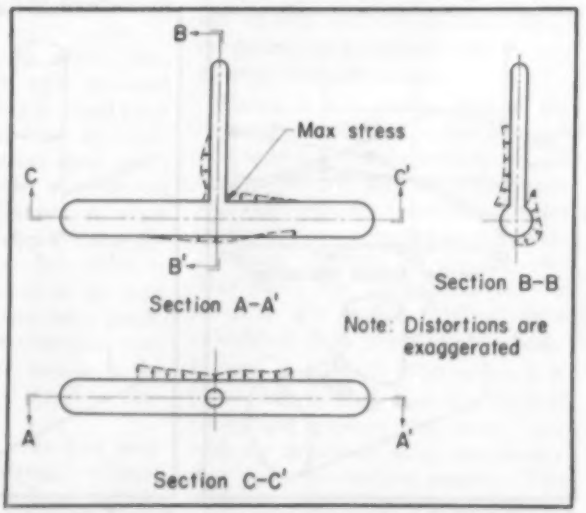


Figure 11. Distortion of 12-inch connection with internal pressure.

New Design Method for Vent Lines

Fanno line and Mollier diagram are used in presentation of a rigorous method for real gases.

Clyde E. Parish and David Cornell,
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Austin

THE DESIGN OF pressure relief systems involves anticipation of possible causes of over-pressure, determination of the capacity of the relief devices and discharge lines, and the mechanical design of the relief system. Sylvander and Katz[6] have presented an extensive study of all of these problems. Lapple[1,4] has developed a procedure assuming ideal gases and adiabatic flow that permits a rapid design of the relief lines. Knowledge of the thermodynamic properties of the gas may be used to design relief lines for real gases.[2] Designs based on the real gas properties have seldom been made because of the numerous steps in the calculations. However, the calculations for real gases are not as difficult as might be expected. The purpose of this paper is the present the calculation procedures to be followed in designing relief piping systems for real gases.

Theory—The energy equation for horizontal, adiabatic flow with no work done is given by Equation (1).

$$\Delta \overline{H} + \frac{\Delta v^2}{(J)\ (2)\ (g_c)} = O \qquad (1)$$

The velocity in terms of the mass rate of flow per unit area is

$$v = \frac{G}{\rho} \qquad (2)$$

Equation (3), called the Fanno equation, gives the enthalpy in terms of the gas density.

$$\Delta \overline{H} + \Delta\left[\frac{G^2}{(2)\ (J)\ (g_c)\ (\rho^2)}\right] = O \quad (3)$$

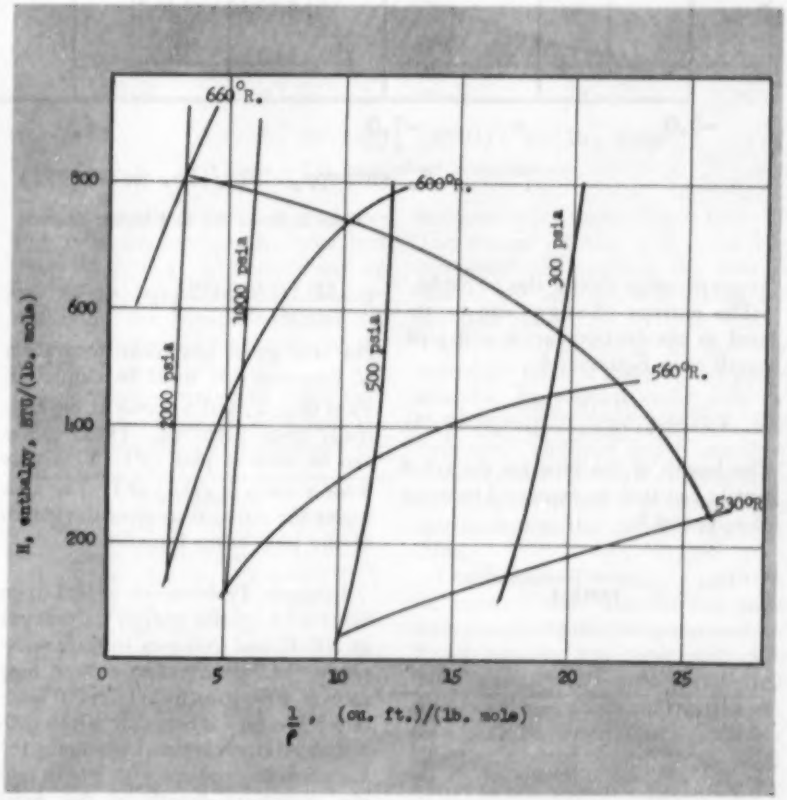

Figure 1. Fanno line with enthalpy-specific volume isobars and isotherms.

Equation (3) gives the variation of gas density with enthalpy changes as the gas flows through the pipe.

A Mollier chart having lines of constant pressure, temperature, and specific volume can be read directly to find the variation of pressure, temperature, and entropy with the enthalpy change indicated by the Fanno equation. If the Mollier chart does not have lines of constant specific volume, a compressibility factor chart can be used to make the calculations. In any case, a plot of enthalpy versus entropy and a plot of enthalpy versus temperature for the conditions of the

Author Parish's present address is Eastern States Petroleum Company, Houston.

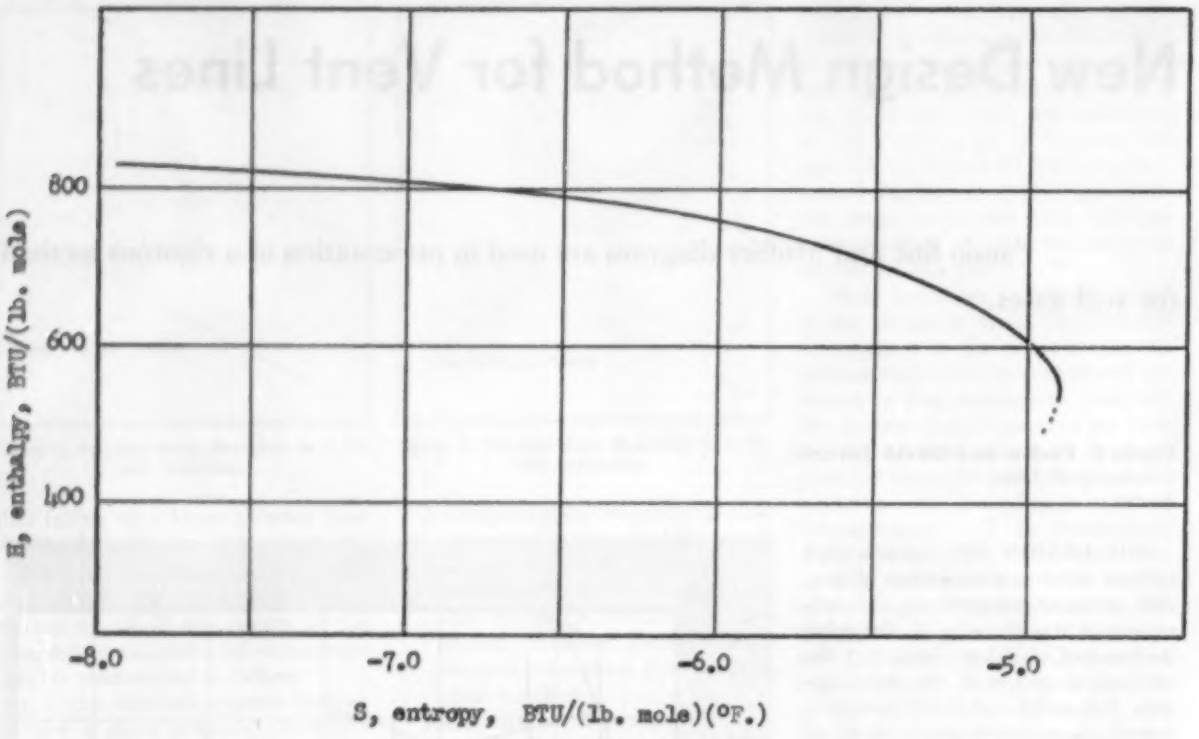

Figure 2. Fanno line on a Mollier diagram.

Fanno equation should also be made.

The entropy changes can be related to the friction factor and pipe length as in Equation 4.

$$T\,\overline{dS} = \frac{(f)\ (G^2)\ (dL)}{(2)\ (g_c)\ (J)\ (D)\ (\rho^2)} \qquad (4)$$

The length of the pipe for the relief system can then be expressed in terms of ρ, T, and S.

TABLE 1

$\frac{1}{\rho}$	H_m
3.2	822
5	812
10	756
15	664
20	535
23	440
25	370

TABLE 2

H_m	T, °R.	P, psia	S	$\frac{1}{\rho}$
822	660	2000	—7.9	3.13
800	625	1000	—6.7	6.35
755	600	650	—6.00	10.0
725	590	500	—5.50	12.1
555	565	300	—4.90	19.5
500	560	280	—4.95	21.5

$$L = \frac{(J)\ (2)\ (g_c)\ (D)}{(f)\ (G^2)} \int (\rho^2)\ (T)\ (\overline{dS}) \qquad (5)$$

For real gases, graphical integration of Equation (5) must be employed. Plots of ρ, T, and $\overline{S}$ versus $\overline{H}$ have already been prepared. These values can be used to plot (ρ^2) (T) versus $\overline{S}$ for a series of values of $\overline{H}$. The area under the curve then gives the length of the pipe using Equation (5).

Example Problem—A relief line vents a 0.6 specific gravity natural gas at 200 F. and 200 psia to the atmosphere (14.7 psia.) The desired flow rate is 800 (pounds)/(feet²) (second.) The pipe is Schedule 40, ½ inch commercial steel pipe. Compute the variation of pressure with length and the maximum length of the relief line.

TABLE 3

S	ρ	T	2.28 p^2T
—7.9	0.319	660	152.0
—6.75	0.158	625	35.4
—5.95	0.100	600	13.68
—5.50	0.083	589	9.14
—4.90	0.0513	565	3.40

Solution:

1. Real gas, adiabatic conditions.

The enthalpy at any point in the pipe is obtained from Equation (3). The initial velocity is zero. On a mole basis Equation (3) becomes

$$H_m = H_{mo} - \frac{(M)\ (G_m^2)}{(2)\ (g_c)\ (J)\ (\rho_m^2)} \qquad (3a)$$

From an enthalpy-entropy diagram,[5] the enthalpy set by the initial conditions is read.

$$H_{mo} = 830 \text{ BTU/pound-mole}$$

$$M = (0.6)\ (28.9 = 17.35$$

$$G = \frac{800}{17.35} = 46.1 \text{ (lb. moles)/(ft.}^2\text{) sec.}$$

Substituting these values in Equation (3a),

$$H = 830 - \frac{(0.737)}{(\rho_m^2)}$$

By assuming values of the density the corresponding values of enthalpy can be calculated. Figure 1 is the plot of this equation. The values plotted in Figure 1 appear in Table 1. To facilitate calculation, constant pressure and temperature lines may be added to Figure 1. Lines of constant specific volume do not appear on the enthalpy-entropy diagram used,

therefore values of specific volume are calculated from the equation.

$$v_m = \frac{zRT}{P} \qquad (6)$$

The z values used are these given by Brown et al.[2]

Interpolating for values of temperature or pressure at a given enthalpy, the value of the entropy is obtained from the Mollier Diagram.[5] The corresponding curve appears in Figure 2. Data for plotting the curve appear in Table 2.

On a mole basis Equation 5 becomes

$$L = \frac{(2)\ (J)\ (g_c)\ (D)}{(M)\ (f)\ (G_m^2)} \int (\rho_m^2)\ (T)\ dS$$

$$= 2.28 \int (\rho_m^2)\ (T)\ dS$$

The above equation is integrated graphically between the initial entropy and the maximum value of entropy from Figure 2. The area under the curve in Figure 3 represents the maximum length of pipe allowable for the given flow rate. The pressure drop to any point in the pipe can be calculated by evaluating the area area corresponding to the desired length. The data for the curve are given in Table 3. (From the Moody friction factor chart,[1] f = 4.027).

$$L\ (\text{maximum}) = 130\ \text{feet}$$

L is an equivalent length which includes entrance effects and losses in fittings. The pressure and temperature of the gas at the end of the pipe are obtained by interpolation from Figure 1.

P = 300 psia.
T = 105 F.

2. Ideal Gas, adiabatic conditions.

The method used is given elsewhere.[1]

$$G_{cal} = P_c \sqrt{\frac{(g_c)\ (M)}{(e)\ (R)\ (T_c)}}$$

$$G_{cal} = 4{,}080\ (\text{lbs.})/(\text{sec.})\ (\text{ft.}^2)$$

$$G_{cal} = \frac{(800)}{(4{,}080)} = 0.196$$

From Figure No. 217, page 205 of Reference (1).

N = 64
L = 121.5 feet

and the pressure and temperature at the discharge end of the pipe are

P = 186 psia.
T = 112 F.

It can be seen that the ideal gas equation gives a conservative result.

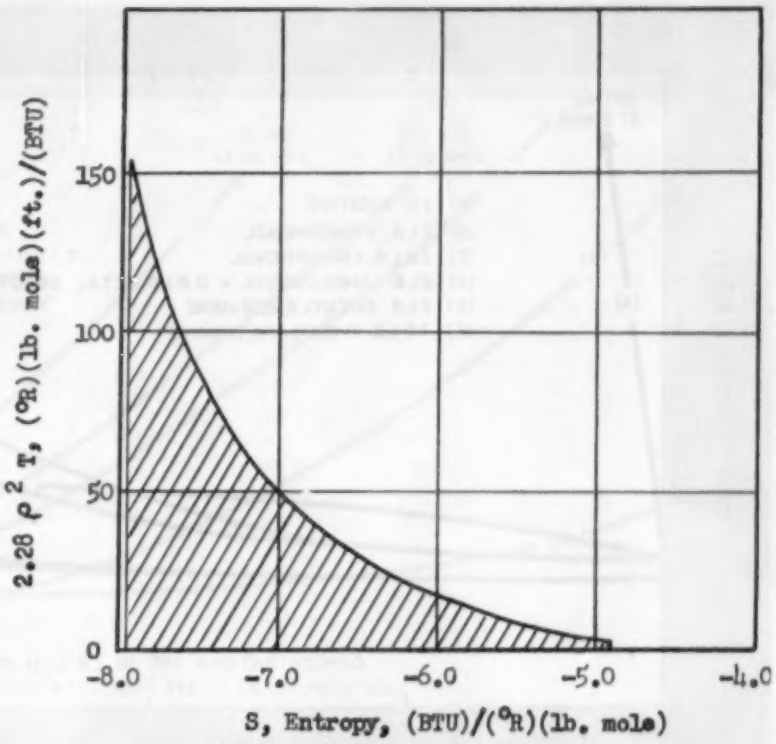

Figure 3. Plot for graphical integration step.

Inclusion of the z factor as a correction of the gas constant, R., in method 2 would give a value approaching that of the rigorous solution. The accuracy of the rigorous solution depends considerably on the size of the Mollier diagram available.

Discussion—Design of relief lines by use of the ideal gas equations are on the conservative side whenever the compressibility factor is less than 1.0 The reason for this is that for low compressibility factors the volume flow of the real gas is less than for the ideal gas.

One disadvantage of the solution procedure for real gases is that problems can be worked easily only by starting with a fixed pipe size and flow rate. The pipe length can then be determined. Because of the graphical integration step it would be difficult to reverse the calculation procedure.

Conclusions—Design procedures for pressure relief lines for real gases based on the Mollier diagram and the Fanno equation have been presented. The calculations are more involved than ideal gas solutions but the results may be more reliable in many cases. # #

Nomenclature

D	Pipe diameter feet
e	2.71828
f	Moody friction factor
G	Mass velocity, (lbs. mass)/(ft.^{2}) (second).
g_c	conversion factor, 32.17 (lbs. mass) (ft.)/(lbs. force) (sec.^{2})
G_{cal}	isothermal critical mass velocity through a nozzle, (lbs. mass)/(ft.^{2}) (second).
$\overline{H}$	enthalpy, Btu/lb. mass
H_m	enthalpy, Btu/lb. mole
J	conversion factor, 778 (ft.)(lbs. force)/(Btu)
L	pipe length, feet
M	molecular weight, (lbs.)
N	$\frac{(f)\ (L)}{(D)}$
o	subscript denoting initial conditions
P	pressure, psia.
ρ	density, (lbs. mass)/(ft.^{3})
ρ_m	density, (lb. moles)/(ft.^{3})
R	gas constant, (lbs. force) (ft.)/(lb. mole) (°R)
$\overline{S}$	entropy, (Btu)/(lb.) (°R)
S_m	entropy, (Btu)/(lb. mole) (°R)
T	Temperature, °R
v	velocity, (ft.)/(sec.)
z	compressibility factor

ACKNOWLEDGMENT

D. E. Zaremba of the Houston Refinery of Shell Oil Company reviewed the manuscript and made several suggestions for its improvement.

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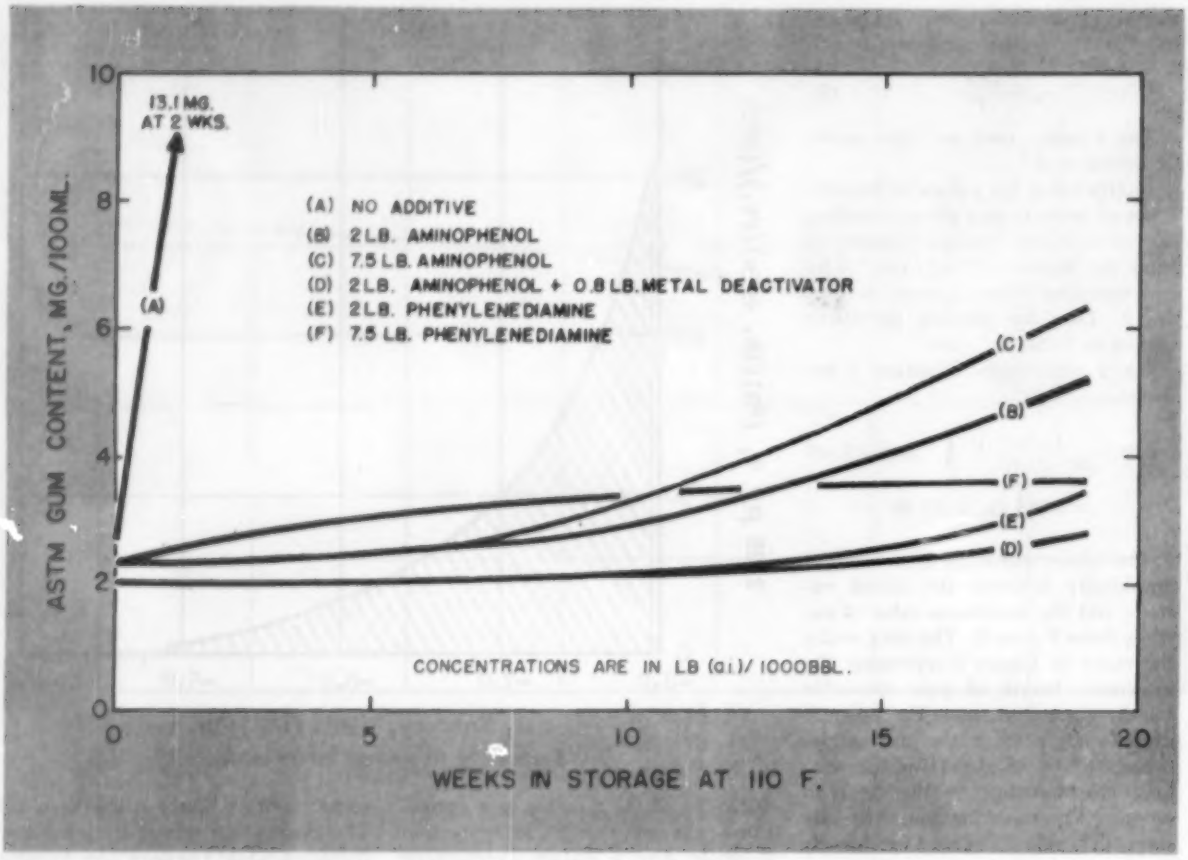

Figure 1. Effectiveness of various additives in reducing gum formation in unleaded cracked shale-oil gasoline during 110 F. storage.

How Stable Is Shale-Oil Gasoline?

Here are the results of tests run to determine the stability of this type gasoline during storage.

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E. I. du Pont de Nemours & Company,
Wilmington, Del.

HOW STABLE is cracked shale-oil gasoline? An investigation of one particular stock indicates that these products are quite unstable; however, they are susceptible to stabilization with the same inhibitors as those used for stabilizing cracked gasolines from petroleum.

Inhibitors have been employed for approximately two decades to help provide gasolines of satisfactory stability. Thermally and catalytically cracked gasoline stocks derived from petroleum and blends containing appreciable amounts of these components have been conveniently and economically stabilized by the use of aminophenol and phenylenediamine type antioxidants. Finished gasolines are usually assured of satisfactory storage characteristics by the use of 2 to 20 pounds per 1000 barrels of one of these antioxidants. Similar satisfactory storage stability can be expected with cracked shale-oil gasolines using these inhibitors.

Gum formation with cracked gasoline stocks is believed partly due to the presence of reactive olefinic hydrocarbons that oxidize to produce materials which subsequently catalyze the oxidation of normally less reactive hydrocarbons. There is evidence also that certain sulfur and nitrogen compounds normally present in fuels contribute to instability and subsequent gum formation. Those components known to cause gasoline instability are generally found to a greater de-

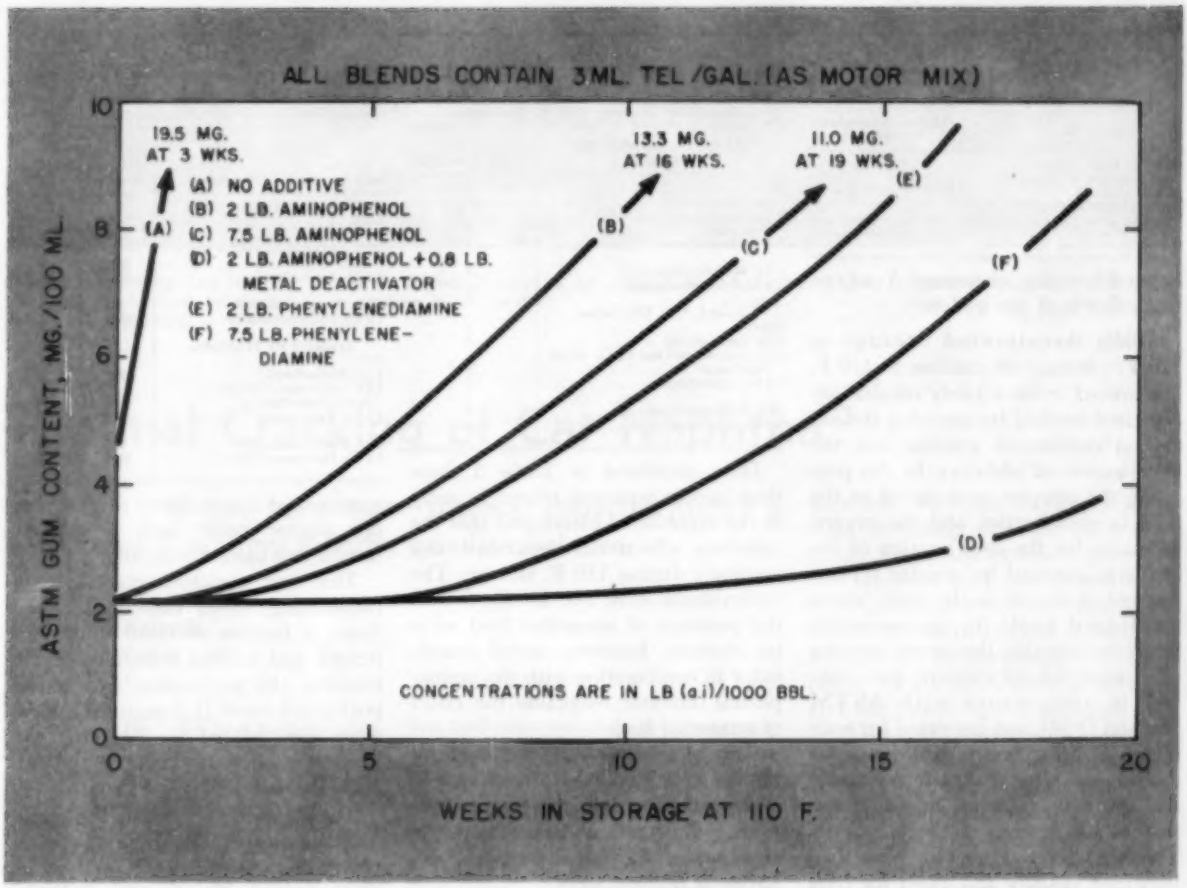

Figure 2. A comparison of the effectiveness of several additives in reducing gum formation in leaded cracked shale-oil gasoline during 110 F. storage.

gree in cracked shale-oil gasoline than in gasoline derived from petroleum.

Experimental—The fuel employed in this study, supplied by the Bureau of Mines Oil-Shale Demonstration Plant at Rifle, Colo., was a cracked shale-oil naphtha, treated with concentrated sulfuric acid and then rerun. To minimize deterioration of the fuel during transit to the laboratory, two portions were inhibited at 2 pounds per 1000 barrels with aminophenol or phenylenediamine antioxidants and shipped under a helium atmosphere. A third portion was uninhibited, but blanketed with helium. The inhibiting and blanketing with an inert gas was accomplished as soon as was practicable after rerunning. Upon the receipt, the fuel samples were placed in cold storage until used.

Certain physical and chemical properties of the fuel are presented in Table 1. Distinguishing characteristics are the relatively high sulfur and nitrogen contents.

TABLE 1

Characteristics of Cracked Shale-Oil Gasoline

ASTM Distillation	
Initial Boiling Point	139 F.
10 Volume Percent	218 F.
50 Volume Percent	295 F.
90 Volume Percent	364 F.
End Point	413 F.
Recovery, Volume Percent	98.5
Residue, Volume Percent	1.0
Loss, Volume Percent	0.5
Olefins, Volume Percent	38
Aromatics, Volume Percent	17
Paraffins and Naphthenes, Volume Percent	45
Specific Gravity, 60/60 F.	0.7624
Sulphur, Weight Percent	0.22
Nitrogen, Weight Percent	0.02
Copper, mg/l.	0.38
Doctor Test	Sweet
Induction Period, ASTM, Minutes	460+
Gum, ASTM, mg/100 ml.	1
Color, Saybolt	+0
Reid Vapor Pressure, Lb.	2.5
Octane Number, Motor Method:	
Clear	55.7
1.5 ml. TEL/gal.	64.6
3.0 ml. TEL/gal.	68.3
Octane Number, Research Method:	
Clear	59.3
1.5 ml. TEL/gal.	68.4
3.0 ml. TEL/gal.	74.4

Laboratory accelerated oxidation tests consisted of induction period (ASTM D 525) and copper dish gum (Federal Specification 330.1.2) determinations. Mildly accelerated storage in glass bottles at 110 F. with frequent gum (ASTM D 381) determinations and visual inspection for haze or precipitation was utilized to determine the stability of the fuel and to evaluate the effectiveness of the additives. Fuel "cleanliness" as pertains to engine intake system deposits was evaluated in a laboratory single-cylinder engine fitted with a suitable heated and baffled manifold.

Table 2 lists the concentrations of the various additives evaluated in both leaded and unleaded fuel.

TABLE 2
Additives Evaluated

ADDITIVE	Lb. (Active Ingredient) Per 1000 Bbls.
N-n-butyl-p-aminophenol	2 and 7.5
N,N'-di-sec-butyl-p-phenylenediamine	2 and 7.5
N-n-butyl-p-aminophenol and N,N'-di-salicylidene-1,2-diaminopropane	2 of aminophenol and 0.8 metal deactivator

Leaded samples contained 3 ml. of tetraethyl lead per gallon.

Mildly Accelerated Storage at 110 F.—Storage of gasoline at 110 F. has proved to be a fairly reliable accelerated method for studying the oxidation stability of gasoline and the effectiveness of additives. In this program, the samples were stored in the dark in glass bottles, and the oxygen necessary for the deterioration of the fuel was supplied by regular replenishment of the air in the space above the liquid level. At approximately monthly intervals, the stored samples were analyzed for existent gum content in accordance with ASTM Method D 381 and inspected for sediment. Prior to gum determinations the samples were shaken to resuspend any insoluble material that had settled to the bottom of the container. The homogeneous samples were then inspected visually and rated for haze or insoluble residue content.

Figures 1 and 2 demonstrate the instability of uninhibited cracked shale-oil gasoline and the effectiveness of the inhibitors and of the aminophenol-metal deactivator combination in retarding the formation of gum during 110 F. storage. It is of interest to note that the base fuel, leaded or unleaded, was extremely unstable. Deterioration proceeded rapidly with the formation of large amounts of gum. The shale-oil gasoline was very responsive to either of the inhibitors. Of the two, the phenylenediamine compound afforded the greater degree of protection. Although the stabilizing effect of the antioxidants alone was substantial, the combination of two pounds of aminophenol inhibitor and 0.8 pound of metal deactivator proved even more effective. These results, which have been encountered previously with cracked petroleum stocks containing small quantities of soluble copper, were not entirely unexpected since the base gasoline was found to contain approximately 0.5 part per million of copper.

TABLE 3
Effect of Additives in Retarding Insoluble Residue Formation in Cracked Shale-Oil Gasoline During 110 F. Storage.

Additive, Lb. (A.I.)/1000 Bbl. Unleaded	Time to Slight Precipitation, Wks.
None	2
2 Lb. Aminophenol	19
2 Lb. Aminophenol and 0.8 Lb. Metal Deactivator	19
7.5 Lb. Aminophenol	12
2 Lb. Phenylenediamine	19
7.5 Lb. Phenylenediamine	12
Leaded, 3 Ml. TEL/Gallon	
None	2
2 Lb. Aminophenol	7
2 Lb. Aminophenol and 0.8 Lb. Metal Deactivator	19
7.5 Lb. Aminophenol	7
2 Lb. Phenylenediamine	7
7.5 Lb. Phenylenediamine	12

Data presented in Table 3 show that hazing occurred relatively early in the uninhibited blends and that the additives effectively retarded this tendency during 110 F. storage. The antioxidants were not as effective in the presence of tetraethyl lead as in its absence; however, metal deactivator in combination with the aminophenol inhibitor overcame the effect of tetraethyl lead.

The blends of unleaded fuel inhibited at 7.5 pounds formed haze in a shorter time than the sample containing 2 pounds of antioxidant. An explanation of this anomalous behavior is not apparent.

Accelerated Oxidation Tests—Prior to storage, induction periods and copper dish gum determinations were obtained on the freshly prepared blends. Results of these accelerated oxidation tests are presented in Table 4. Induction period results show that this fuel, leaded and unleaded, was responsive to both inhibitors. There was a corresponding induction period increase with an increase in inhibitor concentration. The induction period of the samples containing 2 pounds of aminophenol inhibitor was improved substantially by the addition of 0.8 pound of metal deactivator. This improvement was probably attributable to the deactivation of trace amounts of copper present in the fuel and the resulting suppression of its pro-oxidant catalytic activity. Cracked shale-oil gasoline showed only a slight tendency to form copper dish gum. In both leaded and unleaded fuel, the inhibitors were, in general, equally effective in suppressing this tendency.

Engine "Cleanliness"—The tendency of cracked shale-oil gasoline to form intake system deposits was determined in a laboratory single-cylinder engine fitted with a suitably heated and baffled manifold.

TABLE 4
Stability of Cracked Shale-Oil Gasoline as Measured by Accelerated Oxidation Tests.

Additive, Lb. (A.I.)/1000 Bbls.	Induction Period, Minutes	Copper Dish Gum Mg./100 Ml.
Unleaded		
None	205	5.3
2 Lb. Aminophenol	745	4.3
2 Lb. Aminophenol and 0.8 Lb. Metal Deactivator	1067	4.9
7.5 Lb. Aminophenol	1787	2.3
2 Lb. Phenylenediamine	873	4.4
7.5 Lb. Phenylenediamine	1593	4.5
Leaded, 3 Ml TEL/Gallon		
None	85	10.1
2 Lb. Aminophenol	378	7.5
2 Lb. Aminophenol and 0.8 Lb. Metal Deactivator	958	4.1
7.5 Lb. Aminophenol	770	2.4
2 Lb. Phenylenediamine	900	5.8
7.5 Lb. Phenylenediamine	1018	6.0

This test consisted essentially of carbureting, under controlled conditions, a fuel-air mixture through a heated and baffled manifold located between the carburetor and intake port of a Lauson H-2 engine. Deposits were accumulated for 20 hours employing unaged, uninhibited and unleaded cracked shale-oil gasoline.

The deposits formed in the manifold and on the baffled plate were removed with naphtha followed by an acetone wash. The former wash dissolved the hydrocarbon type materials and the latter the naphtha-insoluble materials. Deposits were collected by evaporating the naphtha and acetone solutions to dryness in an ASTM air-jet bath. Naphtha and acetone-soluble deposits weights were 203 and 34 mg., respectively. While field data are extremely limited, it is believed that gasolines having acetone-soluble deposit weights below 200 mg. probably will not cause excessive intake system deposits. By this criterion, cracked shale-oil gasoline in an unaged condition is "clean."

Summary

Laboratory accelerated oxidation tests and mildly accelerated storage tests on a cracked shale-oil gasoline have indicated that:

1. Uninhibited cracked shale-oil gasoline is extremely unstable.
2. It is responsive to the additives used to stabilize cracked gasoline obtained from petroleum.
3. Its storage stability problems are probably very similar to those of cracked gasoline stocks derived from petroleum. ##

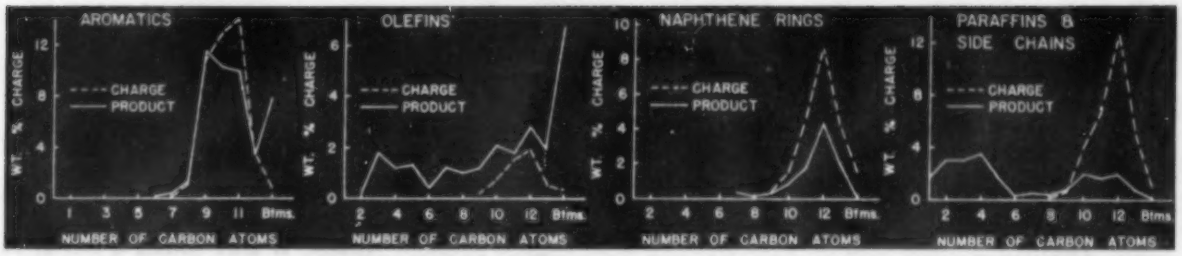

Figure 1. Aromatics: Lost from the C_{10} and C_{11} fractions by thermal cracking.

Figure 2. Olefins: Produced by cracking in all fractions.

Figure 3. Naphthene rings: An overall loss.

Figure 4. Paraffins & side chains: New ones are in the C_1 to C_5 range.

Thermal Cracking of Cat Naphtha?

If you have spare thermal capacity, here's a way to use it and get a better gasoline balance.

Andre W. Pollock,
Sun Oil Company,
Marcus Hook, Pa.

THE THERMAL cracking of catalytic naphtha produces a higher yield of a higher octane gasoline than can be obtained from a comparable straight run naphtha. Even the octane improvement is equal if not slightly better in the case of the catalytic stock. In view of this, the refiner with spare thermal capacity, who has been forced to take a reduction in the yield or octane number of his catalytic gasoline because of the overlap problem, could well afford to investigate the thermal processing of catalytic naphtha.

In refineries where the catalytic gasoline cracked from virgin gas oil is cut to a high enough end point to include uncracked charge stock, the high boiling fraction of the gasoline is a low octane component. To meet an increased octane number goal, the refiner may feel compelled to cut a lower end point gasoline and eliminate this material. This, of course, would mean a loss in gasoline yield.

Such an expedient could be avoided by removing from the fresh gas oil charge to catalytic cracking the low boiling fraction which passes unchanged through the catalytic unit, and upgrading that fraction by thermal reforming. A yield loss would still be incurred, however, this time due to losses in the thermal operation. A more effective method would be to accept the lower catalytic gasoline end point but then if the capacity were available, thermally crack a large enough high boiling catalytic naphtha sidestream to regain gasoline production. The loss in yield due to thermal operation would be charged, in this case, not to catalytic gasoline but, rather, to first pass catalytic gas oil.

Thermal Charge Stocks—To determine whether there was any disadvantage in thermal cracking catalytic naphtha we prepared two stocks of comparable boiling ranges—one from catalytic, the other from virgin stock. Their characteristics are shown in Table 1. Note the large difference in gravities and octane numbers between the naphthas. This is attributable to the higher aromaticity of the cracked stock. It may also, in some measure, be due to the presence in the catalytic naphtha of more branched paraffins.

Pilot Plant Results—Both of these naphthas, the virgin and the catalytic, were thermally cracked in a pilot plant. The plant consisted simply of two stainless steel coils immersed in lead baths and series connected by an electrically heated transfer line. The second coil outlet pressure is maintained by a control valve at 600 psig and the charge rate is adjusted for a cracking coil residence time of 50 to 60 seconds. A separator operating at 40 psig returns liquid product as quench to the second coil outlet.

A summary of the results of these runs is shown in Table 2. By the term "limiting cracking depth" we mean the maximum yield by weight of C_5 and lighter components that can be attained in a thermal cracker without excessive coking. Of course, the depth values in the table can be increased with more frequent shutdowns or if a more favorable heating curve can be achieved.

The octane improvement is the difference between the Research clear octane numbers of the product gasoline and of the charge. For a debutanized gasoline fractionated to obtain a 390 F. at 90 percent point, both stocks show an octane improvement of 34. For a 405 F. at 90 percent gasoline, the octane improvement for the catalytic feed is 33 and for the virgin, 31. Cutting the higher end point gaso-

TABLE 1
Characteristics of Charge Stock

	Catalytic	Straight-Run
I.B.P.	380	409
10 Percent	406	422
50 Percent	431	432
90 Percent	470	455
End Point	512	492
Gravity, °API	32.2	60.6
Octane Number (Research Clear)	65	40
Percent by Weight:		
Olefin	49	1
Aromatic		14
Naphthene	22	31
Paraffin	29	54

TABLE 2
Thermal Cracking of Naphtha

	Catalytic		Straight-Run	
Limiting Cracking Depth	10		12	
Debutanized Gasolines:				
90 Percent Point, °F	390	405	390	405
Yield, (Volume Percent)	47	60	48	55
Octane Number (Research Clear)	99	98	74	71
Octane Improvement (Research Clear)	34	33	34	31

line gives a 13 percent rise in yield for the catalytic and only a 7 percent increase for the straight run charge. We can see, therefore, that it is possible in thermal cracking catalytic naphtha to cut a higher end point gasoline without suffering as much octane depreciation.

Other products are derived from the thermal cracking of catalytic naphtha and are shown in Table 3. We have broken down the C_3 and C_4 components because of the interest in unsaturates for making polymer and alkylate gasolines.

Chemical Composition Data—Table 4[1] shows the change in hydrocarbon types of a catalytic naphtha and the combined liquid and gas product from thermal cracking. It shows a net decrease in paraffins plus side chains and naphthenic rings, a considerable increase in olefins, and a very slight increase in aromatics.

Figures 1 to 4 show the distribution of charge and product for each hydrocarbon type. According to Figure 1,[1] aromatics are lost from the C_{10} and C_{11} fractions by thermal cracking. At the same time there is a production of aromatics above C_{12} that seems to be the result of condensation reactions. The over-all weight percent increase of aromatics based on charge is 2 percent, as shown in Figure 1, indicating little aromatic production from other hydrocarbon types.

New olefins are produced by cracking in all fractions (see Figure 2). The over-all increase in olefins is 19 weight percent of charge.

There is an over-all loss in naphthene rings due to cracking of 11 weight percent of charge (see Figure 3). Little of this, we suspect, may be attributed to dehydrogenation to aromatics since the over-all aromatics content has only increased by 2 percent. It can be attributed to the formation of cyclic olefins or the splitting of naphthene rings.

TABLE 3
Thermal Cracking of Catalytic Naphtha C₄ & Lighter Components

	Liquid Volume Percent Charge
C_3 and Lighter, FOE	6.4
Propylene	3.2
Propane	4.2
i-Butene	0.9
Butylenes	3.0
n-Butane	2.2

The major portion of new paraffins (see Figure 4) is in the C_1 to C_5 range of the product. Few paraffins are formed in the C_6, C_7, and C_8 fractions, and there is an over-all decrease in paraffins of 9 weight percent.

Thermal cracking, in short, removes naphthenes and paraffins, produces some heavy aromatics by condensation reaction, and produces a large quantity of olefins.

Some may justly question the use of the word thermal cracking instead of thermal reforming to describe the processing of catalytic naphtha. We have used the word "thermal cracking" because the main reaction is the production of olefins by cracking of higher molecular weight compounds. There is no doubt, however, that some dehydrogenation and isomerization take place and certainly the product gasoline contains some of this material. Perhaps a more pertinent question should be "Why call this fraction catalytic naphtha?" The reason is that in the work done on cycle gas oil,[2] initialling at about 450 F., the results have always shown the cycle stock to give a poorer yield of a poorer octane gasoline than the straight run stock of comparable boiling range. This does not hold true for the lighter, more aromatic catalytic fraction which has been considered in this study. Being able to operate at higher levels of cracking severity and cutting a gasoline which includes considerable material boiling in the range of the charge, the yield and octanes are higher for the catalytic over the virgin feed. We may thus describe the operation as a process—part thermal reforming, part thermal cracking—on a fraction—part catalytic naphtha and part catalytic gas oil.

Refinery Applications—The application of this technique may be shown by considering, for a moment, a refinery situation where the catalytic gasoline is being cut at a 90 percent point of 380 F. and has a Research clear octane number of 89. Cutting a 335 at 90 percent gasoline would increase the octane to 92, but a 5 percent reduction in yield from fresh gas oil would result. The large octane increment is a strong indication that there is uncracked naphtha in the overlap between the tail end of the gasoline and the front end of the charge. If after cutting a 335 at 90 percent gasoline a catalytic naphtha stream representing about 9 percent of the fresh gas oil charge were thermally cracked, the octane number of the blended catalytic and thermal gasoline would still be 92 and there would be no gasoline production loss. Thermal gasoline would be cut at a 90 percent point of about 410 F., which may seem unusually high. However, the blended gasoline would have a 90 percent point slightly less than the original 380 F at 90 percent gasoline.

TABLE 4
Thermal Cracking of Catalytic Naphtha Over-All Composition Change

	Weight Percent Charge
Paraffins and Side Chains	— 9.1
Naphthene Rings	—11.2
Olefins	+18.6
Aromatics	+ 1.6

This operation requires a considerable amount of thermal cracking capacity. Refiners who are replacing thermal with catalytic reforming, however, may find that this would be the most efficient method of using their idle units. Certainly if they are faced with the problem of low octane overlap in their catalytic gasoline it represents a possible solution. Even those refiners who now undercut their catalytic gasoline to avoid overlap may find that they could retain their octane number and increase their yield by this operation.

Direct attack upon the overlap problem at the crude tower may cost more than it is worth. It cannot be solved merely by raising the cut point of the fresh catalytic feed since too much valuable gas oil cracking stock would be lost in the naphtha or kerosine cut. It is necessary rather to sharply cut the front end of the fresh gas oil by means of improved crude fractionation. Since this will probably require more fractionation towers, and still does not avoid a gasoline yield loss, one may find that this expedient would be considerably less economical than accepting the overlap and upgrading it by thermal cracking.

Original presentation was at the American Chemical Society fall meeting, New York, September 11-17, 1954. ##

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Making Aldehydes from Petroleum

In this, the second of three parts, the discussion of the petrochemical routes for the production of aliphatic aldehydes is continued. Methods covered here are the Oxo process, aldolization and aldol conversion and partial oxidation.

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AS A COMMERCIAL source of aldehydes, the Oxo reaction made its debut in 1952 when Tennessee Eastman Corporation first began the manufacture of *n*- and *iso*butyraldehyde from propylene at Longview, Texas. Even before this, the process had found industrial use as intermediate step in the synthesis of iso-octyl and tridecyl alcohol from a petroleum-derived heptene or dodecene fraction. This is the route taken by Esso Standard Oil Company at Baton Rouge (which started Oxo operations in 1949) by Standard Oil Company (Indiana), Wood River, Illinois, by Gulf Oil Corporation, Port Arthur, Texas, and by Carbide & Carbon Chemicals Company for Texas City. In these installations, the Oxo stage is followed directly by hydrogenation of the intermediate C8-aldehyde.

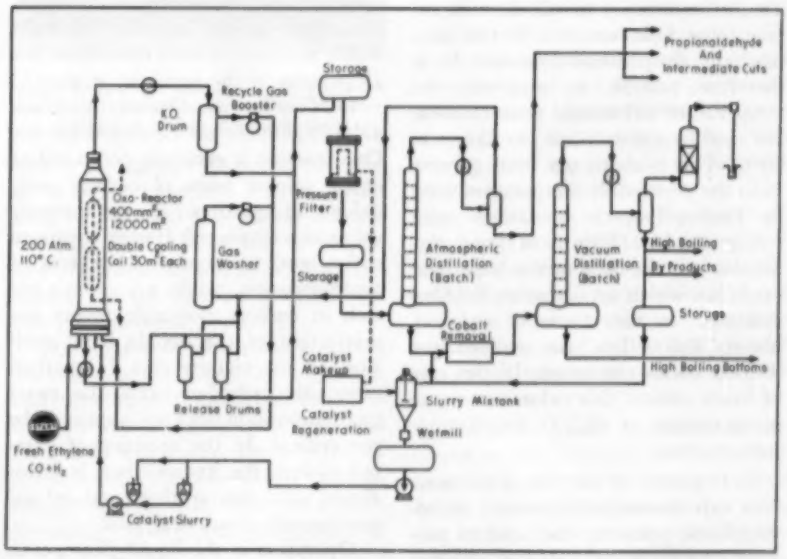


Figure 1. Simplified flowsheet of the Oxo process. Here the process is applied to the manufacture of propionaldehyde from the synthesis gas.

Route 2, Aldehydes by the Oxo Process—This new unit process — the Oxo synthesis—involves the simultaneous reaction of carbon monoxide and hydrogen (synthesis gas) with an olefin to yield an aldehyde containing one more carbon atom than the feedstock.

$$R-CH=CH_2 + CO + H_2 \begin{cases} \rightarrow R-CH(CH_3)-C(=O)-H \\ \rightarrow R-CH_2-CH_2-CHO \end{cases} \quad (1)$$

As a source of aldehydes, both actual and potential, the great attraction of the Oxo process rests in its remarkable versatility. It takes place with a host of olefinic and acetylenic compounds. In the laboratory, olefins ranging from ethylene to diisobutylene, from cyclohexene to pinene, and from ethyl acrylate to styrene, have been successfully subjected to the Oxo reaction, often with yields in excess of 90 percent.

The Oxo reaction is carried out in the liquid phase in every commercial instance. The controlling variables are catalyst, operating pressure and temperature and, to a more limited extent, the suspension medium.

1. *Catalyst:* An active form of cobalt is universally employed in the Oxo reaction. The work of Adkins[1] and others indicates that the active principle or the Oxo catalyst is cobalt hydrocarbonyl.

In the absence of sulfur compounds, cobalt catalyst will result in the formation of a product containing at least 20-40 percent alcohols. Where the formation of aldehydes rather than alcohols is the desired objective, the addition of a small amount of sulfur compounds has proved useful. This is without signficant effect on the progress of the Oxo reaction but it suppresses alcohol formation almost completely.

2. *Temperature:* Operation at low temperatures has the advantage of permitting reduction in system pressure. The required temperature level is, to a certain extent dependent on the olefin feedstock and on the activity of the cobalt catalyst. In general, Oxo temperatures are in the range, 100-145 C. (100-115 C. for conversion of ethylene, 120-145 C. for higher olefins). To operate effectively in this low temperature range, active forms of cobalt, such as those described, must be employed. With this type of catalyst, oxoation of normally liquid olefins has been reported at temperatures as low as 45-65 C. However, reaction rates at this level are unsatisfactory.

At temperatures between 150 and 190 C., almost any cobalt salt can be used as Oxo catalyst. Here, the opti-

mum temperature depends on the ease with which the salt is converted to the active catalyst (cobalt hydrocarbonyl or dicobalt octacarbonyl). An accompanying phenomenon of operation at higher temperatures is the increasing formation of alcohols in the primary Oxo stage of the process. At 180-200 C., oxoation of ethylene in hydrocarbon suspension leads completely to n-propanol.

By the standards of the Fischer-Tropsch synthesis, to which it is related, the Oxo reaction is not particularly temperature-sensitive. It is therefore possible to maintain the temperature differential between coolant and reaction phase as large as 20 C. This is about ten times greater than the permissible temperature drop in Fischer-Tropsch operations with cobalt catalyst. This is of great significance in the light of the large heat evolution which accompanies the Oxo synthesis. In the course of reaction, about 50,000 Btu are evolved per lb-mole olefin converted. In the case of lower olefins, this value rises up to a maximum of 62,500 Btu/lb-mole for ethylene.

3. *Pressure:* While the Oxo reaction can theoretically proceed at atmospheric pressure, the need to prevent decomposition of the catalyst, dicobalt octacarbonyl, calls for partial pressures of carbon monoxide in excess of 40 atmospheres (at 150 C.). Accordingly, the Oxo reaction is generally run at system pressures in the range of 100-250 atmospheres.

Natta and Beati[3] have reported that the rate of oxoation is independent of pressure above 75 atmospheres. This finding is not confirmed in experimental continuous operations carried out at Ruhrchemie. In these laboratory runs, the following effective conversion was reported as a function of pressure. Contact time was one hour; $CO:H_2$ ratio was 1.

Pressure (atm)	Approximate Conversion (%)
50	10
100	50
150	70-80
275	95

Orchin and Schroeder[4] ascribe the discrepancy between these two sets of experimental findings to poor contact between synthesis gas and reaction phase under the continuous operating conditions at Ruhrchemie. This limitation is expected to impose a minimum requirement of 125-150 atmospheres for oxoation in continuous flow.

Operating pressure may, in certain cases, also affect the composition of the product. Thus, the Oxo reaction of ethylene at 125 atmospheres results in the formation of 22 percent diethyl ketone, while this by-product is totally absent at 500 atmospheres. Propylene conversion at normal Oxo conditions (100-250 atm.) yields n-butyraldehyde and isobutyraldehyde in the ratio 4:6. Boosting the system pressure to 700 atm. reportedly favors formation of the normal aldehyde which accounts, at such conditions, for 75 percent of the isomeric product.[4]

4. *Miscellaneous Operating Variables:* Synthesis gas employed for the Oxo reaction is generally composed of equal volume parts of carbon monoxide and hydrogen; i.e. the theoretical ratio is employed. Higher hydrogen ratios tend to increase the extent of hydrogenation, while a synthesis gas rich in carbon monoxide favors isomerization of the double bond position. In the vicinity of a 1:1 carbon monoxide:hydrogen ratio, the exact gas composition does not appear to be too critical. In the oxoation of gaseous olefins, the hydrocarbon is introduced with the synthesis gas in approximately theoretical ratio.

Operation in the liquid phase, even for the production of propionaldehyde and butyraldehyde, permits a ready solution to the problem of heat removal and reduces the extent of catalyst fouling and decomposition. Where liquid olefins are oxoated, the feedstock itself is used as suspension medium. Complete olefin conversion is generally taken in a single pass.

In the Oxo synthesis with gaseous olefins, an auxiliary suspension medium must be employed. Usually an inert hydrocarbon is selected which differs in boiling point sufficiently from the resulting aldehyde to permit ready separation.

Scope of the Oxo Process — The Oxo reaction leads to a complex mixture of isomeric aldehydes and primary alcohols. In addition, a number of side reactions take place during the synthesis to form esters, ketones, and polymerization products. By the choice of proper operating conditions, these side reactions can, however, be minimized, and yields can be realized in the range of 70-90 percent of theory.

In order to facilitate product purification, it is universally necessary to start with a pure olefinic stock. In spite of this precaution the end product must be thoroughly fractionated. However, aldehydes above C_5 would have to be subjected to such drastic conditions of distillation that large amounts of the reactive aldehydes would be converted to esters (by disproportionation), aldols (by condensation), and other undesired by-products. The yield of aldehydes eventually becomes so low that recovery by this method becomes prohibitive.

In work done to date with higher olefins, it has therefore been common practice to convert the primary products directly to more stable compounds prior to separation. The most frequent means selected is the hydrogenation to alcohols which can be more readily purified. The isolated alcohols can be subsequently oxidized to the desired aldehyde.

No such stringent precautions are necessary in the production of low-boiling aldehydes. Propionaldehyde can be readily purified by fractionation. Not much greater difficulties are encountered in the production of butyraldehyde. The two isomers n- and i-butyraldehyde exhibit a sufficiently low boiling point and a large enough boiling point spread to permit adequate separation by distillation.

Valeraldehydes are the last in the series of Oxo aldehydes which can be freely separated from the primary product.

Technology of Oxo Synthesis — Two versions of the Oxo process have come into commercial operation. The techniques differ chiefly in the means used for contacting catlyst with reaction medium. The older system provides cobalt catalyst as a slurry in the feedstock (or auxiliary suspension medium). More recently, fixed-bed processing has come to the fore. The newer method eliminates the need for filtration and some solids handling which is associated with the slurry-type process. This advantage is achieved at the cost of reduced space velocity.

(a) Slurry Technique

In this process the charge stock is mixed with the required quantity of cobalt-base catalyst. In the case of a catalyst akin to the Fischer-Tropsch composition, the proper weight range is 3-5 percent. Most of this catalyst mass is recycle material; make-up requirements are small.

The slurry is boosted to reaction temperature and pressure and is fed to the bottom of a primary reactor which it enters concurrently with a stream of synthesis gas. About two-thirds of the gas is a recycle stream, the remainder being make-up. To be sure, this ratio is quite variable and influences the reactor design significantly. The gas stream acts as heat carrier and is capable of removing an appreciable portion of the total heat of reaction. It will thus reduce the cooling surface requirements within the reactor. Beyond this, the agitating action of the feed gas is of signficant influence on the speed of conversion. The actual gas recycle ratio is selected by economic compromise.

About 70 percent conversion takes place in the first reactor. The reaction is taken to completion in a secondary Oxo converter. This separation into two (and even three) successive reactor chambers reduces the extent of intermingling between product and feedstock. Furthermore, the final stages of the reaction can be speeded up by operating the second reactors some 10-20 C. above the reaction temperature of the first unit if alcohol formation is not objectionable. Additional amounts of synthesis gas are fed to the bottom of the second reactor which is also operated in concurrent fashion.

Total contact time is of the order of 20-30 minutes. About one-third of the total reaction takes place during the first two minutes, and it is at this stage that cooling requirements are most critical. In addition to the cooling action of the gas, indirect heat removal must be effected, either by the use of cooling tubes in the (primary) Oxo reactor or by external heat exchangers. The use of carbon steel is satisfactory for reactor construction.

The reactor effluent leaving the top of the second Oxo reactor is separated from the gas phase in a knock-out drum. With the exception of a small bleed stream, required to prevent build-up of inerts, the gas is recycled to the reactor system via a gas cooler.

The crude Oxo product is released to atmospheric pressure. After removal of suspended catalyst by filtration, the mixture is ready for separation by distillative means or for hydrogenation to Oxo alcohols.

(b) Fixed-bed Practice

Use of a suitable fixed-bed Oxo process offers the advantages of eliminating the catalyst filtration step and some solids handling. Proper means must be provided to overcome difficulties due to the large heat evolution and the deterioration of the catalyst caused by the formation of soluble and volatile cobalt carbonyl.

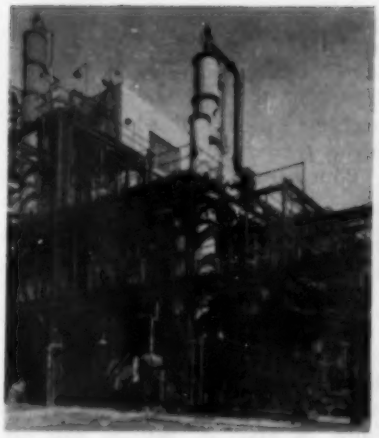


Figure 2. Reaction and distillation equipment used in the production of acrolein. (Courtesy, Carbide & Carbon Chemicals Co.)

One approach, which has attracted attention, is the Reppe system, originally developed at Ludwigshafen. The fundamental catalyst is cobalt carbonyl formed in situ during the progress of the reaction over a fixed-bed catalyst, consisting of metallic cobalt on a pumice carrier. The initial cobalt content is 2 percent.

To make up cobalt losses, this metal is introduced with the olefinic feedstock in the form of the soluble salt of a fatty acid. The olefinic charge, together with synthesis gas ($CO:H_2 = 1.0$) is fed to the top of the Oxo reactor (one to three units may be used in series as in the slurry process). A considerable excess of gas is employed, partly to act as heat carrier and partly to ensure complete conversion of the hydrocarbon stock. Most of this excess gas is recycled to the Oxo reaction stage.

Liquid effluent from the Oxo converters is separated from the gas phase and is fed to a partial hydrogenation (decobalting) converter for the destruction of dissolved cobalt carbonyl. This unit is filled with pumice on which the metallic cobalt deposits as it is formed. The treatment is carried out in the presence of hydrogen at 200 atmospheres and at approximately 120 C.

The carrier is permitted to build up a cobalt content of not more than 10 percent and must be regenerated periodically. This may be brought about by passing high-pressure carbon monoxide through the converter.

Oxo Manufacture of Propionaldehyde—The specific case of ethylene oxoation is exemplified by a plant designed by I. G. Farbenindustrie for the Italian firm Bombrini-Parodi-Delfino. While this plant was never actually constructed, it illustrates well the design basis for the production of lower aldehydes by the Oxo route.

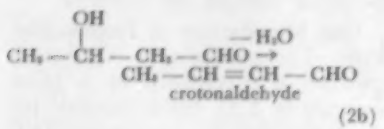
Figure 1 is a flow sheet of the Bombrini plant. Ethylene, water gas and recycle gas enter the bottom of the reactor while the cobalt catalyst, dispersed through toluene, which is used as start-up solvent in this particular plant, enters counter-currently near the top of the reactor. The gases leaving the reactor are cooled and scrubbed for aldehyde recovery. The gas is recycled after having been fortified with make-up synthesis gas. Bottoms of the reactor are cooled and filtered. Propionaldehyde is distilled out from the product mixture. The bottoms are recycled to the reactor and the cobalt catalyst is re-used without regeneration.

The heavy products, formed in the course of the reaction, were expected to serve as solvent, obviating the necessity for outside replacement of toluene losses. The catalyst must be replaced periodically. Only about 5 pounds catalyst is required per 100 pounds working liquid. Operation at 90-100 C. and 150 atmospheres was proposed. Yields of about 60-70 percent were expected.

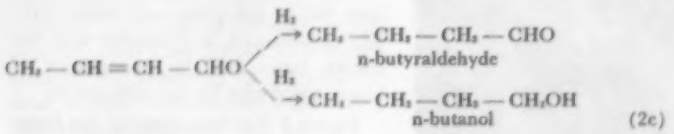
Route 3, Aldolization and Aldol Conversion—The ability of two aldehyde molecules to undergo a condensation (aldolization) reaction underlies an important process for the production of aldehydes of medium molecular weight.

The method finds its most important application in the production of croton-aldehyde (intermediate in the manufacture of n-butyraldehyde and n-butanol). Output in 1953 of this chemical is estimated at 210-240 million pounds. Acetaldehyde serves as raw material. Following is the overall production scheme leading via crotonaldehyde to its saturated derivatives:

$$2\,CH_3CHO \rightleftharpoons \underset{\text{Aldol}}{CH_3-\overset{\overset{OH}{|}}{CH}-CH_2-CHO} \qquad (2a)$$

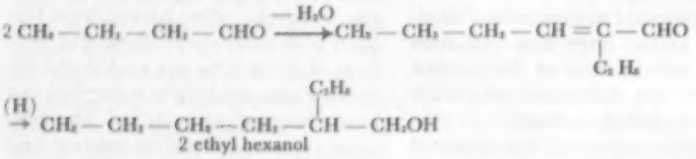


(2b)



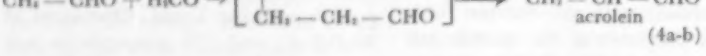
(2c)

A somewhat similar reaction scheme serves to synthesize 2-ethyl hexanol from two molecules of n-butyraldehyde. This process is employed commercially by Tennessee Eastman Company and Carbide and Carbon Chemical Company.



(3a-c)

On a much smaller scale, aldolization-dehydration is also used for the production of acrolein from formaldehyde and acetaldehyde. Here, the entire conversion takes place in a single step:



(4a-b)

Production of Aldol — Today, the importance of this compound is wholly due to its subsequent conversion to crotonaldehyde. During the war, however, very large volumes of aldol served in the German economy as intermediate in butadiene synthesis.

The homo-condensation of acetaldehyde, taking place in accordance with Equation (2a), is an equilibrium reaction. The conversion is catalyzed by aqueous caustic. Low aldolization temperatures must be maintained in order to minimize losses to higher condensation products. Commercial plants are being operated over the entire range from 5 to 25 C. At the higher temperatures (as well as for the production of high-purity aldol), by-product formation must be suppressed by shorter contact time and lower acetaldehyde conversion per pass (45-50 percent vs. 55-60 percent at 5-10 C.). The advantage of operating in a range where mechanical refrigeration is unnecessary is obvious, and the modern trend favors the higher temperatures.

Both caustic soda and potassium hydroxide are being used as condensation agents. Either catalyst is supplied in app. 10 percent aqueous solution and should be substantially free of carbonates. Usual (but not universal) practice is to carry out aldolization in two stages. In the first stage, the reaction liquor is continuously recirculated and acetaldehyde (free of acid) as well as make-up caustic are continuously introduced. Catalyst concentration is controlled to a titer of 1.1-1.5 ml of N/2 hydrochloric acid per 100 ml aldol.[5] Conversion taken in the first aldolizer differs between plants but normally does not exceed 40-45 percent.

The overflow of the first reactor enters a second aldolizer in which the reaction is allowed to proceed to completion (60 percent over-all conversion). In both units the same operating temperature is maintained. The two-stage arrangement reduces higher condensation reactions by assuring low caustic concentration throughout the finishing (secondary) aldolizer equipment.

As we have indicated, operation at 25 C. can be carried out with better efficiency by stopping the reaction short of equilibrium conversion. In this case, therefore, single-stage operation serves satisfactorily.

Facilities must be provided for adequate removal of the exothermic heat of aldolization. In most installations, the primary reactor consists in effect of standard shell-and-tube heat exchange equipment. The reaction phase is circulated through the tubes which are surrounded by cooling tubes (or brine).

Where a 2-stage reaction system is employed, the cooling load in the secondary reactor is relatively low and the hold-up time may be as high as 5-6 hours (vs. 1-1.5 hours in the first aldolizer). An agitated tank with cooling coils may therefore serve adequately for the finishing stage. Mild steel is used in reactor construction.

Where the desired product is crotonaldehyde, crude aldol leaving the final condensation stage (and containing 45-60 percent acetaldol) is acidified by means of acetic or phosphoric acid. It is then fed to the dehydration column. (Different measures must be taken if pure aldol is to be isolated since heating in the presence of acids unavoidably causes dehydration, and neutral or slightly alkaline salts catalyze resinification and other yield-consuming side reactions.)

It is entirely feasible to combine *dehydration to crotonaldehyde* and primary distillation of product in a single operation. In a typical installation practicing this technique, the dehydration system consists of one acetaldehyde still and one crotonaldehyde column together with auxiliary equipment. Copper construction is used.

In a somewhat more efficient dehydration, the aldol is converted in contact with a relatively large volume of acid salt solution. Here, the dehydrating agent is phosphoric acid and its acid sodium salts (cf. Figure 2). The reactor is a lead-lined tower, 2.2 foot diameter x 36 feet high, surmounted by a 9-foot high Raschig ring-packed scrubbing section of 1.5 foot diameter. Dehydration proper is effected in the unit's lower part, three-quarters of which is filled with an aqueous solution of sodium acid phosphate at 30-35 percent concentration (pH of 4). The liquor is held at 95 C. Crude aldol, together with 33 percent phosphoric acid solution, enters near the top of the dehydration section. Acetaldehyde (containing 2

percent crotonaldehyde) is evolved and leaves through the packed column top where it is scrubbed with a recycled water stream.

The main body of reaction liquid is continuously circulated through an external heat exchanger. A small stream is withdrawn to separators for stratification into crotonaldehyde and aqueous layers. The inorganic phase is fortified by sodium acid phosphate and returned to the reaction column.

The volatile acetaldehyde stream, withdrawn as overhead from the reactor, is purified by atmospheric distillation. Crotonaldehyde, contained in the aqueous bottoms, is dried by azeotropic means.

The main stream of crude crotonaldehyde, separated from dehydrator liquor, is introduced into a packed column (1.2 feet diameter x 18 feet high) where it is dried by azeotropic distillation. The crotonaldehyde-water azeotrope is taken overhead, is separated into layers, and the organic phase is refluxed to the column.

Dried crude crotonaldehyde, leaving the base of the azeotroping still at 104 C., is fed to a packed rectifying column (1.5 feet diameter x 18 feet high), built of carbon steel. Product is taken overhead in 98-99 percent purity.

Over-all crotonaldehyde yield in this operation has been reported at values up to 95-96 percent of theory (based on acetaldehyde feed to dehydrator).

Conversion to Butyraldehyde and n-Butanol—The hydrogenation of crotonaldehyde may be guided to yield predominantly butyraldehyde or n-butanol.

One commercial version of the process leading to the alcohol employs a catalyst of copper on pumice. The reaction is carried out in the vapor phase at 180-220 C. and atmospheric pressure. Reactor feed contains about 3.5 volume percent crotonaldehyde in hydrogen. Most of the gas is a recycle stream, and only 7-8 percent of it is make-up (98 percent) hydrogen.

Substantially complete conversion takes place in a single pass. The reactor effluent is cooled to 5-10 C. and the condensate is freed of sludge (catalyst dust) prior to distillation. Yield of crude butanol is 95-96 percent (on crotonaldehyde). It assays 86 percent n-butanol, ½ percent butyraldehyde, ½ percent higher

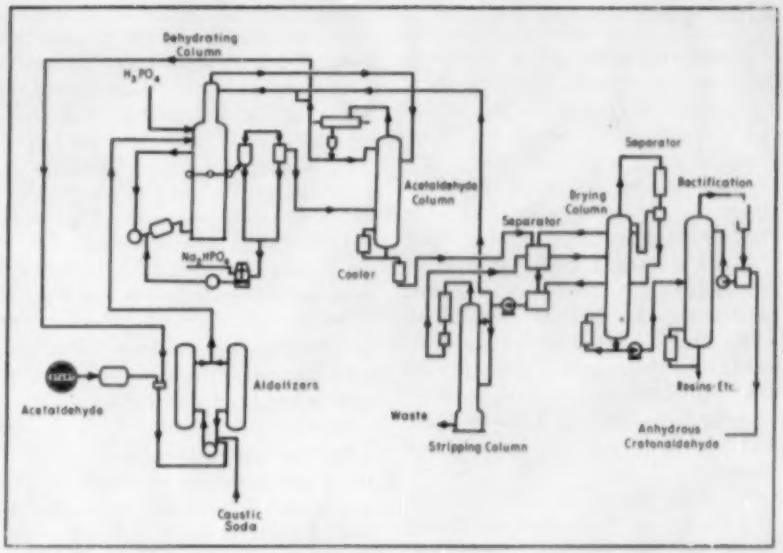


Figure 3. Production of crotonaldehyde from acetaldehyde utilizing the mechanism of aldol condensation.

products, and 10 percent water. Standard distillation methods yield butyraldehyde and purified n-butanol. By operating the hydrogenation at mild conditions (e.g. fresh catalyst at 175 C. or spent catalyst at 200 C.), butyraldehyde formation can be raised to as much as 15 percent of total conversion.

Crotonaldehyde may be converted preferentially to butyraldehyde by hydrogenation over a mild catalyst. One plant uses an aqueous (40 percent) slurry of nickel on pumice, prepared from nickel carbonate on pumice by thermal decomposition and hydrogen reduction. On a dry basis, the catalyst contains 13 percent nickel.

The catalyst slurry is suspended in crotonaldehyde and some limestone is added to neutralize contained acid. The mix is contacted with hydrogen at 25-30 atmospheres and 30-35 C. Product contains 70-80 percent butyraldehyde, 4-5 percent crotonaldehyde, 10 percent water, and some high-boiling by-products. Butanol formation is small. Butyraldehyde is isolated by fractionation.

Acrolein Production by Condensation—The instability of hydracrylaldehyde in the presence of bases prevents the synthesis of acrolein from formaldehyde and acetaldehyde by the conventional (liquid-phase) techniques employed in aldol condensation. Instead, all attempts to carry out the reaction in this fashion have led to the predominant formation of acetaldol and hence to crotonaldehyde.

It is, however, possible to condense formaldehyde with acetaldehyde to form acrolein in good yield, by operating in the vapor phase. A highly effective catalyst for this conversion is alkalized silica gel, produced by impregnation of silica gel with 10 percent sodium silicate.[6]

Feed is an equimolar mixture of acetaldehyde and formaldehyde (supplied as 30-37 percent aqueous solution). Use of higher acetaldehyde ratios leads to undesirably high crotonaldehyde formation, while excess formaldehyde complicates the problem of later formaldehyde recovery.

The charge stream is fed continuously to a vaporizer, followed by a superheater. From here, it enters the catalytic converter which is operated at 300-320 C. and atmospheric pressure. Apparent contact time (i.e. calculated to the bulk volume of catalyst employed) is of the order of 3-4 seconds. Typical conversion per pass achieved at these conditions is 44-46 percent of the initial acetaldehyde and 50-52 percent of formaldehyde.

Reactor effluent is cooled for the condensation of product and unconverted raw materials. Waste gas is water-scrubbed before venting, and the resulting aqueous solution is combined with the crude reactor make.

The combined liquid phase enters a primary column in which acrolein

and unreacted acetaldehyde are taken overhead. Separation between these components is effected in the acetaldehyde column in which this raw material is isolated overhead while purified product acrolein is withdrawn as a side stream from the tower's bottom third.

A 10 percent aqueous solution of formaldehyde is withdrawn as bottom product of the primary distillation unit. This may be concentrated by fractionation under pressure (15 psig), to obtain an overhead of 30-40 percent formaldehyde strength, feasible for recycling to the synthesis stage.

Over-all acrolein yield in this process is 72-75 percent of theory, based on formaldehyde, and 79-82 percent, on acetaldehyde. The method may also be used for the condensation of formaldehyde with suitable homologues of acetaldehyde to obtain alpha-alkylated acroleins. Here, even better efficiencies are attained, and alpha-methyl or alpha-ethyl acrolein have been synthesized in quantitative per-pass conversion and in yields exceeding those for acrolein.

Route 4, Partial Oxidation of Hydrocarbons — A mixture of aldehydes and other valuable oxygenated compounds may be obtained by direct oxidation of hydrocarbons. Different processes, embodying this principle, have found commercial application in U. S. plants operated by Cities Service Oil Company, Celanese Corporation of America, and McCarthy Chemical Company (not now in operation).

Three different basic approaches to partial combustion of hydrocarbons may be discerned: (a) non-catalytic operation, (b) heterogeneous catalysis, and (c) homogeneous catalysis. Each of these is represented among existing plants for the direct conversion of hydrocarbons to aldehydes.

(a) *Non-Catalytic Operation*

Willstaetter and Bomer[7] and Blair and Wheeler[8] made classical studies of conditions favorable to the thermal oxidation of hydrocarbons to useful organic products. These authors found that the oxidation of ethylene is still very slow at 350 C., the temperature at which ethylene begins to be unstable. At the same time, the main useful reaction product—formaldehyde—is unstable at temperatures above 310 C. It is therefore necessary to operate with low concentration of both ethylene and formaldehyde and to permit only low conversion per pass, keeping the time of heating at a minimum. By extreme observance of these requirements, Blair and Wheeler were able to obtain a 75 percent of theory yield of formaldehyde by the oxidation of ethylene at 575 C. It was necessary, however, to recycle the gases so many times and to maintain conversion per pass at such a low level that the process had only academic interest.

In the case of methane, which is thermally much more stable, it was not necessary to dilute the hydrocarbon. By maintaining an oxygen deficiency and again taking a very low conversion per pass and short heating time, it was possible to oxidize methane to formaldehyde with 65.5 percent yield at 720 C.

In general, lower temperatures can be successfully employed for the partial oxidation of higher hydrocarbons than for the lower members of the family. This observation has been made the basis for a process of Celanese Corporation for the manufacture of lower aldehydes and other oxygenated products by the partial oxidation of butane and propane.

In this process, air, together with diluent steam, is preheated independently of the feed hydrocarbon with which it is mixed at a point just preceding the converter chamber.

For good yields, careful control of feed ratio and contact time is of paramount importance. With butane, the best reaction time is between 1 and 1.5 seconds. Immediately following the converter, the effluent gases are quenched below 180 C. by a water spray. Following further cooling and condensation the products are ready for separation. Incidentally, extremely severe purification problems are encountered with the complex mixture of oxygenated compounds which are formed in the process.

Quite as important as space velocity is the ratio of air to hydrocarbon in determining the yield of useful products. Bludworth[9] brackets the optimum ratio between 9 and 11 volumes air per volume butane. Above this value, complete combustion and other side reactions make excessive inroads on yield.

Steam serves as diluent to prevent formation of an explosive system, as well as to prevent runaway reactions. To achieve this two-fold goal, 100-120 volumes steam per volume hydrocarbon are required.

This process for the partial oxidation of hydrocarbons is carried out at elevated pressures (300-400 psi) which favors the formation of oxygenated chemicals.

Having set the ratio of feed streams and the contact time, the preheat temperature determines the temperature level attained in the reactor chamber. Decomposition temperature (approximately 230-250 C.) sets an effective limitation to the extent of hydrocarbon preheat. Actually, the organic feedstock is kept well below this level up to the point of juncture with the combustion agent. To bring the feed mixture up to the required initiation temperature, the steam-air stream is preheated independently to 400-450 C.

Yield and product composition are, of course, subject to wide variation as a function of changes in operating conditions. A typical illustration is provided by the oxidation of butane in admixture with 10 volumes air and 110 volumes steam. The hydrocarbon is preheated to 150 C. while the other components are fed to the reactor at 400 C. Operating pressure is 300-400 psi, and contact time is 1.15 seconds. At these conditions, 100 pounds butane will yield:

15.2 pounds formaldehyde
19.6 pounds acetaldehyde
7 pounds acetone
19 pounds methanol
1 pound n-propanol
0.5 pound butyl alcohol
11.4 pounds organic acids

Upon condensation, the organic compounds form, of course, only a relatively small portion of the total liquid—most of which is water. The purification is simplified—and over-all yields are raised—by recycling this water to the quench tower following the reactor, after it has been separated from the products of partial oxidation.

(b) *Heterogeneous Catalysis*

The necessity for carrying out thermal oxidation at temperatures at which aldehydes are not stable has led to the development of catalytic oxidation processes. The first patent for the catalytic oxidation of methane to formaldehyde is due to G. Glock[10]

who recommends the use of a copper catalyst. Since 1898, the date of issuance of the Glock patent, a host of other patents has recommended almost every conceivable metal and metal salt as oxidation catalyst.

For the conversion of methane to formaldehyde, Medwedev[11] reports good results with mixtures of the borates and phosphates of tin, iron, and aluminum. Useful yield was favored by the introduction of small amounts of hydrogen chloride with the feedstream. Starting with a mixture of 58.2 percent methane, 26.1 percent oxygen, 8.7 percent nitrogen, 7.0 percent hydrogen, to which 0.13 percent HCl had been added, per-pass formaldehyde yield at 600 C. was as high is 8.8 percent of theory (based on methane). Ultimate yield, allowing for unconverted methane, ran as high as 15.2 percent.

For the partial oxidation plant of Cities Service Oil Company at Tallant, Okla., J. C. Walker and associates developed a process for the complete reaction of all the oxygen present at elevated temperatures and pressures. The process appears to follow the general approach outlined in Walker's patent.[12]

According to this, the catalyst is a mixture of aluminum phosphate and copper oxide. The reaction is carried out at 450-475 C. and a pressure of about 300 psi. Low conversion per pass and high recycle ratio are used. 1000 cubic feet natural gas (60 percent methane) yield 2.5 gallons liquid reaction product containing 5.4 weight percent acetaldehyde, 12.0 percent formaldehyde and 30.7 percent methanol, together with lesser amounts of acetone, dimethyl acetone, and higher alcohols. Most of the remainder is water formed in the course of oxidation.

Special interest attaches to the production of acrolein by the partial oxidation of propylene in the presence of cuprous oxide catalyst. This process is reported to be in commercial operation at Shell Chemical Company's Houston plant.[13]

The process, which uses air as oxidizing agent, is characterized by high specificity; i.e. carbon dioxide (and water) is the only by-product formed in significant amount.

The catalyst is cuprous oxide on a suitable carrier such as silicon carbide, silica gel or alumina.[13] It is prepared by impregnating the carrier with an aqueous solution of copper nitrate until it contains the desired amount (up to 20 percent) of copper. The mass is then dried in air between 250 and 400 C., and is finally reduced in hydrogen. The oxide must be in the cuprous form. Cupric oxide is not effective for the desired catalytic conversion.

It is indicated that good acrolein yield can be attained in the following range of operating conditions:

- Oxygen concentration in feed, 4 to 8 percent
- Propylene:oxygen feed ratio, 4:1 to 10:1
- Balance of reaction mixture, steam, nitrogen, or other inerts
- Apparent contact time, 0.1 to 2 seconds
- Pressure, 1 to 10 atmospheres

For best yield, conversion per pass must be limited by control of contact time and temperature. As these conditions are chosen more drastically, carbon dioxide formation rises rapidly.

Hearne[14] obtained an 86 percent yield of crude acrolein (based on consumed propylene) with a feed mixture containing 7.8 percent oxygen, 27.6 percent propylene, 35.3 percent steam and about 29.3 percent nitrogen. In this work, operating pressure was 37 psia, and the conversion was carried out at 348 C. over a catalyst containing 1.43 percent copper (as cuprous oxide) on porous silicon carbide. By choosing a contact time of 0.8 seconds, only 24 percent of the initial oxygen reacted in a single pass.

Acrolein may be recovered from the product gases by absorption in water. It is purified by distillative methods. If oxygen is used as oxidizing agent, the bulk of scrubbed gases may be recirculated directly to the reaction stage. In air oxidation, the spent gases may be freed of contained hydrocarbon by an oil wash before they are passed to vent.

(c) *Homogeneous Catalysis in Hydrocarbon Oxidation*

Good preferential production of aldehydes by hydrocarbon oxidation has been achieved by the use of gas phase catalysts. The tested catalysts include HCl, HBr, chlorine, ozone, nitrogen oxides, SO_3 and others. These additives are used per se or in conjunction with solid catalysts.

Illustrative of the latter approach is the work of I. G. Farbenindustrie[15] in which a 90:10 methane:oxygen mixture, containing 2 percent chlorine, was passed over a mixture of cerium, cadmium, and aluminum phosphates at atmospheric pressure and 650 C. to obtain formaldehyde in yields of 25-30 percent (based on methane). According to Schmitt and Rintorff[16], methane can be oxidized to formaldehyde in 90 percent yield by using ozonized oxygen or air over a catalyst consisting of barium peroxide and (0.5 percent) silver oxide promoter on a porcelain carrier. The reaction is carried out at 100-120 C. Per-pass conversion is taken at 25-30 percent. The oxidation of ethane under similar conditions is claimed to give good yields of acetaldehyde, while oxidation of propane is said to lead to propionaldehyde.

Among true gas-phase catalysts, particularly good results have been reported for nitrogen oxides. By the addition of small amounts of nitrogen oxides to a mixture of hydrocarbons and air, Bibb and Lucas[17] were able to obtain formaldehyde with a conversion of 4 percent per pass. Sheely and King[18] oxidized a naphtha fraction with air in the presence of a nitrogen oxide catalyst and obtained a yield of 19.7 percent aldehydes and 25.4 percent carboxylic acids.

Homogeneous catalysts by nitrogen oxide is the basis for the methane-to-formaldehyde process of Gute Hoffnungshuette[19] which was placed into commercial operation at Copsa Mica in the early 1940's. This process is carried out at substantially atmospheric pressure which favors the formation of aldehydes (elevated pressure leads to alcohol production in increasing measure).

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1. At Stanolind's research center in Tulsa, much study was devoted to hydrocarbon synthesis and this information is now being used in revamping the recently acquired Carthage gas synthesis plant at Brownsville, Texas.

2. Four-story building houses this tower which is part of the plant's gas generating equipment.

This Pilot Plant Led to Carthage

3. Pilot plant consists of much multi-purpose equipment. This compressor area plays a major role in pilot plant operations.

4. Storage tanks hold products of gas synthesis process. Most of plant's ms small-scale production is used in further process research.

Vapor Constants for Benzene Equilibrium

Hitherto unpublished data on constants for benzene, including those at higher temperatures and pressures are presented.

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THE INCREASED production of benzene by the petroleum industry necessitates the determination of the best possible thermodynamic and equilibrium data for this compound. The thermodynamic data presented by Organick and Studhalter[4] represent the most recent and extensive study in this field. Drickamer and Bradford[2] determined the ideal vaporization equilibrium constants over a limited range of temperatures and pressures, utilizing the restricted experimental data which were available at the time. It is the purpose of this paper to present the vaporization equilibrium constants for benzene, which have been revaluated over the range of temperatures and pressures included in Drickamer and Bradford's study and new constants for higher temperatures and pressures. The data of Organick and Studhalter[4] were used in calculating values for the entire range of pressures and temperatures.

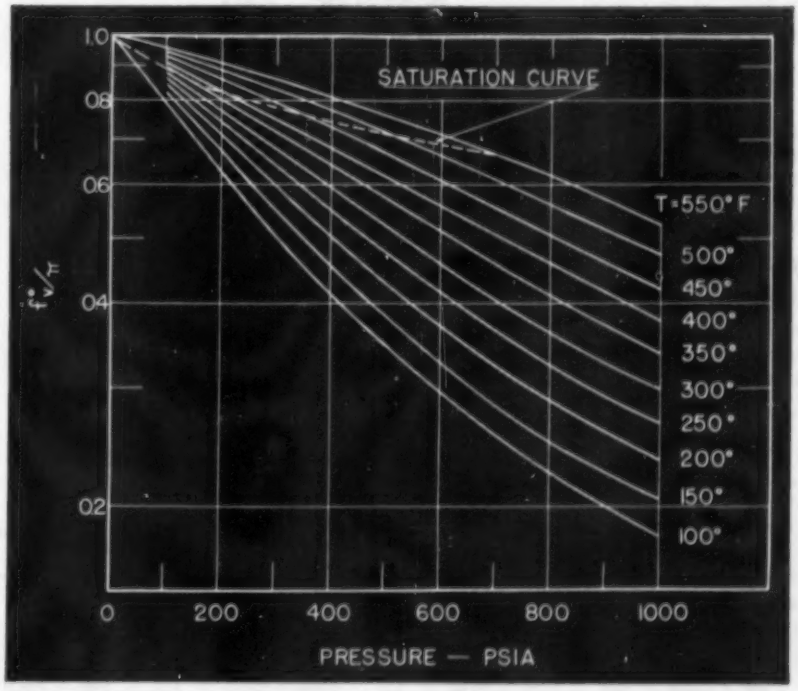

Figure 1. Standard state vapor fugacity of benzene divided by total pressure vs. total pressure.

The need for accurate values of the vaporization equilibrium constant, defined as being equal to the ratio of the fugacity of the pure liquid at the temperature and pressure of the system to the fugacity of the pure vapor at the temperature and pressure of the system, or in symbolic form:

$$K = \frac{f_L^\circ}{f_v^\circ} \qquad (1),$$

is evident, for benzene is normally produced in mixtures of compounds and, therefore, requires a fractionation for purification. In order to design equipment for the separation of benzene from a mixture, values of y/x for benzene are needed. In this ratio y is the mole fraction of benzene in the vapor phase and x is the mole fraction of benzene in the liquid phase, the two phases being in equilibrium. At the present time one of the best approaches to the calculation of this information appears to be through the use of vaporization equilibrium constants in conjunction with the activity coefficients.

The liquid phase activity coefficient, γ, of a component in a liquid mixture is defined as:

$$\gamma = \frac{a_L}{x} \qquad (2),$$

where a_L, the liquid phase activity $= \frac{\bar{f}_L}{f_L^\circ}$; $\bar{f}_L$ = the fugacity of the component in the liquid mixture. Equation (2) may then be rewritten as:

$$\gamma = \frac{f_L}{f_L^\circ x} \qquad (3).$$

Similarly, the vapor phase activity coefficient, ψ, of a component in a vapor mixture may be defined as:

$$\psi = \frac{a_v}{y} \qquad (4),$$

where a_v, the vapor phase activity

Vapor Equilibrium Constants for Benzene . . .

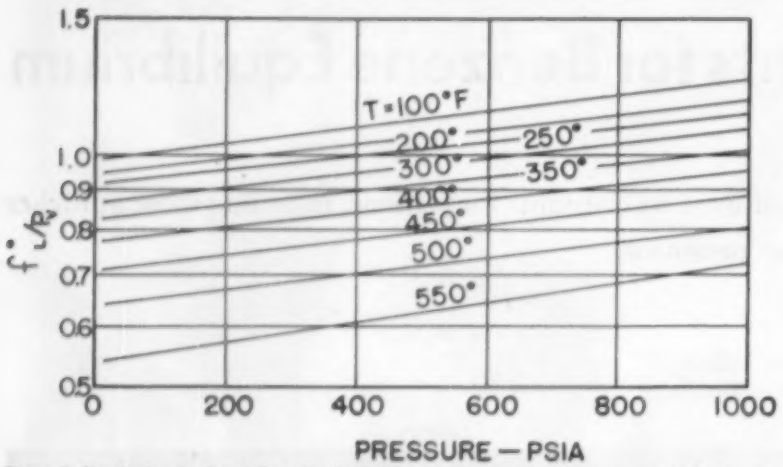

Figure 2. Standard state liquid fugacity divided by vapor pressure of benzene vs. total pressure.

$= \frac{\bar{f}_v}{f_v^\circ}$; $\bar{f}_v$ = the fugacity of the component in the vapor mixture. Equation (4) may be rewritten as:

$$\psi = \frac{\bar{f}_v}{f_v^\circ y} \qquad (5).$$

Combining equations (3) and (5) and solving for y/x one obtains:

$$\frac{y}{x} = \frac{f_L^\circ}{f_v^\circ} \frac{\bar{f}_v}{\bar{f}_L} \frac{\gamma}{\psi} \qquad (6).$$

Since the liquid and vapor phases are in equilibrium, by definition:

$$\bar{f}_v = \bar{f}_L \qquad (7);$$

thus, Equation (6) reduces to:

$$\frac{y}{x} = \frac{f_L^\circ}{f_v^\circ} \frac{\gamma}{\psi} \qquad (8).$$

Substituting Equation (1) in (8) yields:

$$\frac{y}{x} = K \frac{\gamma}{\psi} \qquad (9).$$

The vaporization equilibrium constant, K, is a function of temperature and pressure of the system while the activity coefficient depend upon composition as well as temperature and pressure of the multicomponent mixture.

Since f°_v and f°_L values are needed for the determination of vaporization equilibrium constants, methods for representing f°_v and f°_L as functions of temperature and pressure may be justified through the use of Equation (9). In many cases, the value of the vapor phase activity coefficient, ψ, is unity. Under this condition Equation (9) may be written in the form used by Benedict, et al. (1):

$$\ln \frac{y}{x} = \ln \frac{P_v}{\pi} + \frac{(\pi - P_v)(V - \beta)}{RT} + \ln \gamma \qquad (10),$$

where π = pressure of the system at equilibrium,
T = absolute temperature of the system at equilibrium
P_v = vapor pressure of the component concerned at the temperature of the system,
V = liquid molal volume of the component concerned at the temperature and pressure of the system,
β = second virial coefficient for the component concerned at the temperature and pressure

TABLE 1
Fugacity and Vaporization Equilibrium Constants for Benzene

	100 F. (3.22)*			150 F. (9.22)			200 F. (21.73)			250 F. (44.38)			300 F. (81.86)		
	FUGACITY		Vapor Equil. Constant	FUGACITY		Vapor Equil. Constant	FUGACITY		Vapor Equil. Constant	FUGACITY		Vapor Equil. Constant	FUGACITY		Vapor Equil. Constant
	Gas	Liquid		Gas	Liquid		Gas	Liquid		Gas	Liquid		Gas	Liquid	
Dew Pt.	3.18	...	1.00	8.96	...	1.00	20.7	...	1.00	41.1	...	1.00	72.9	...	1.00
Bubble Pt.	...	3.18	1.00	...	8.96	1.00	...	20.7	1.00	...	41.1	1.00	...	72.9	1.00
14.7	(14.2)†	3.19	0.225	(14.2)	8.97	0.627	14.2	(20.6)	1.45	14.2	(40.85)	2.86	14.4	(71.9)	4.99
25	(23.5)	3.20	0.136	(23.8)	9.00	0.378	(23.8)	20.8	0.873	23.9	(40.94)	1.71	24.1	(72.0)	2.99
50	(45.0)	3.22	0.0715	(45.3)	9.05	0.200	(46.0)	21.0	0.456	(46.2)	41.14	0.890	46.7	(72.4)	1.55
100	(80.1)	3.26	0.0406	(82.0)	9.15	0.112	(84.1)	21.1	0.250	(86.1)	41.63	0.484	(88.0)	73.2	0.832
150	(101.9)	3.29	0.0323	(111.0)	9.26	0.0834	(115.5)	21.3	0.184	(120.0)	42.05	0.350	(123.2)	73.9	0.600
200	(125.0)	3.34	0.0267	(134.0)	9.36	0.0699	(142.0)	21.5	0.151	(148.2)	42.50	0.287	(154.2)	74.7	0.484
300	(150.0)	3.42	0.0228	(162.3)	9.58	0.0590	(178.8)	22.0	0.123	(191.7)	43.40	0.226	(204.0)	76.3	0.374
400	(164.0)	3.50	0.0213	(180.0)	9.80	0.0554	(199.2)	22.5	0.113	(219.6)	44.35	0.202	(237.2)	77.9	0.328
600	(177.6)	3.56	0.0200	(197.4)	10.28	0.0520	(222.0)	23.5	0.106	(251.4)	46.32	0.184	(273.0)	81.3	0.298
800	(180.6)	3.86	0.0214	(204.0)	10.75	0.0527	(230.4)	24.6	0.107	(258.4)	48.33	0.187	(288.8)	84.8	0.294
1000	(181.0)	4.05	0.0224	(206.0)	11.25	0.0546	(234.0)	25.7	0.110	(266.0)	50.55	0.190	(299.0)	88.4	0.296

* Figures in parentheses are vapor pressures expressed in psia. † Fugacity values in parentheses are those in the hypothetical states.

TABLE 1 — Continued

	350 F. (138.9)			400 F. (221.0)			450 F. (336.7)			500 F. (493.5)			550 F. (700.4)		
	FUGACITY		Vapor Equil. Constant	FUGACITY		Vapor Equil. Constant	FUGACITY		Vapor Equil. Constant	FUGACITY		Vapor Equil. Constant	FUGACITY		Vapor Equil. Constant
	Gas	Liquid		Gas	Liquid		Gas	Liquid		Gas	Liquid		Gas	Liquid	
Dew Pt.	118.1	...	1.00	179.0	...	1.00	257.9	...	1.00	353.8	...	1.00	465.1	...	1.00
Bubble Pt.	...	118.1	1.00	...	179.0	1.00	...	257.9	1.00	...	353.8	1.00	...	465.1	1.00
14.7	14.4	(115.0)	7.82	14.5	(171.5)	11.83	14.5	(240.4)	16.58	14.6	(317.0)	21.71	14.6	(379.5)	25.99
25	24.3	(115.4)	4.75	24.4	(171.8)	7.04	24.6	(240.9)	9.79	24.6	(317.7)	12.91	24.7	(380.5)	15.40
50	47.4	(116.0)	2.45	47.9	(172.8)	3.61	48.3	(242.2)	5.01	48.6	(319.8)	6.58	48.9	(384.2)	7.86
100	89.3	(117.2)	1.31	91.4	(174.5)	1.91	93.6	(245.3)	2.62	94.2	(323.3)	3.43	95.2	(389.8)	4.09
150	(127.4)	118.3	0.929	130.7	(176.3)	1.35	134.4	(247.8)	1.84	137.1	(327.3)	2.39	139.2	(395.3)	2.89
200	(160.2)	119.6	0.747	168.6	(178.3)	1.08	172.2	(250.4)	1.45	177.0	(330.8)	1.87	181.2	(400.9)	2.21
300	(216.3)	122.1	0.564	(228.0)	182.0	0.798	237.6	(255.8)	1.08	248.7	(338.6)	1.36	257.4	(413.0)	1.60
400	(260.0)	124.7	0.480	(278.0)	185.8	0.668	(291.2)	261.5	0.898	310.0	(346.4)	1.12	324.0	(425.6)	1.31
600	(304.8)	130.0	0.427	(334.8)	193.7	0.579	(363.0)	272.9	0.752	(390.0)	362.6	0.930	430.2	(452.1)	1.05
800	(324.0)	135.6	0.419	(360.0)	201.9	0.561	(400.0)	284.7	0.712	(444.0)	379.6	0.855	(492.0)	479.1	0.974
1000	(338.0)	141.2	0.418	(377.0)	210.5	0.558	(423.0)	297.4	0.703	(473.0)	398.4	0.842	(525.0)	508.4	0.968

of the system, and
R = gas law constant.

Equation (10) may be rewritten:

$$\frac{y}{x} = e^{\frac{(\pi - P_V)(V - \beta)}{RT}} \frac{P_V}{\pi} \gamma \quad (11).$$

Equation (11) is a relationship between y/x and pressure, volume, and temperature data; whereas, Equation (9) is a relationship between y/x and the fugacities of the pure liquid and vapor.

Comparison of Equation (11) with Equation (9) for the case of $\psi = 1$ shows:

$$K = e^{\frac{(\pi - P_V)(V - \beta)}{RT}} \frac{P_V}{\pi} \quad (12).$$

Combination of Equations (1) and (12) gives:

$$\frac{f_V^\circ}{\pi} = \frac{f_L^\circ}{P_V} \frac{1}{e^{\frac{(\pi - P_V)(V - \beta)}{RT}}} \quad (13).$$

From the fundamental definition of fugacity,

$$d \ln f = \frac{V^*}{RT} d\pi \quad (14),$$

where V^* = the molal volume of the fluid, it may be shown that:

$$f_L^\circ = f P_V e^{\frac{V}{RT}(\pi - P_V)} \quad (15),$$

$$\text{Since } f_{P_V} = \left(\frac{f}{p}\right)_{P_V} P_V \quad (16),$$

where f_{P_V} = fugacity at temperature T, and corresponding vapor pressure.

it follows that:

$$\frac{f_L^\circ}{P_V} = \left(\frac{f}{p}\right)_{P_V} e^{\frac{V}{RT}(\pi - P_V)} \quad (17).$$

Substitution of Equation (17) into Equation (13) gives:

$$\frac{f_V^\circ}{\pi} = \left(\frac{f}{p}\right)_{P_V} e^{\frac{\beta}{RT}(\pi - P_V)} \quad (18).$$

Rewriting Equation (18) gives:

$$\ln \frac{f_V^\circ}{\pi} = \frac{\beta}{RT}\pi + \ln\left(\frac{f}{p}\right)_{P_V} - \frac{\beta}{RT} P_V \quad (19),$$

and rewriting Equation (17) gives

$$\ln \frac{f_L^\circ}{P_V} = \frac{V}{RT}\pi + \ln\left(\frac{f}{p}\right)_{P_V} - \frac{V}{RT} P_V \quad (20).$$

Equations (19) and (20) are equations for straight lines of the general type, $y = mx + b$. Consequently, values for f_V° may be conveniently represented by a plot of $\ln \frac{f_V^\circ}{\pi}$ vs. pressure for constant temperatures because the combinations of terms,

$$\ln\left(\frac{f}{p}\right)_{P_V} - \frac{\beta}{RT} P_V,$$

is essentially a function of temperature only. Likewise, values of f°_L may be conveniently represented by a plot of $\ln \frac{f_L^\circ}{P_V}$ vs. pressure since the combination of terms,

$$\ln\left(\frac{f}{p}\right)_{P_V} - \frac{V}{RT} P_V$$

is also essentially a function of temperature only.

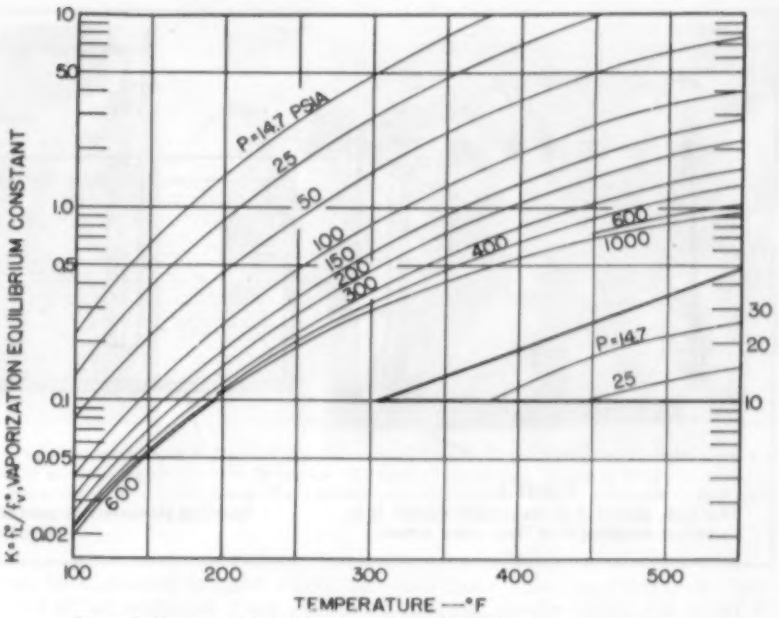

Figure 3. Vaporization equilibrium constant, K, for benzene vs. temperature.

Table 1 shows values of f°_L, f°_V, and K as functions of pressure for constant temperatures. Figure 1 shows values for $\frac{f_V^\circ}{\pi}$ plotted as $\ln \frac{f_V^\circ}{\pi}$ vs. total pressure with parameters of temperature. Figure 2 shows values of $\frac{f_L^\circ}{P_V}$ plotted as $\ln \frac{f_L^\circ}{P_V}$ vs. total pressure with parameters of temperature.

Values for f°_V at pressures below the vapor pressure were calculated from $\frac{f}{p}$ data given by Organick and Studhalter,[4] and those above the vapor pressure, from the generalized $\frac{f}{p}$ chart of Gamson and Watson.[3] Figure 1 shows the values for $\ln \frac{f_V^\circ}{\pi}$, at a constant temperature, in the hypothetical vapor region to lie on an extension of the line representing the $\ln \frac{f_V^\circ}{\pi}$ values in the region where the system pressure is less than the vapor pressure. The lines are somewhat curved at high pressures; the reason for this being that an equation of state containing only the second virial coefficient does not accurately describe the behavior of a gas at these conditions.

Values for f°_L were obtained through the use of Equation (15). Values for f_{P_V} and V were obtained from the data of Organick and Studhalter.[4] In the calculations, V was assumed to be independent of pressure. Figure 2 shows the constant temperature lines on a plot of $\ln \frac{f_L^\circ}{P_V}$ vs. pressure to be straight, as predicted by Equation (20).

Figure 3 shows values of ln K vs. temperature for constant pressures. This is the most useful way of presenting vaporization equilibrium constants, since most equipment is designed to operate at nearly constant pressure but with a temperature gradient.

This investigation confirms the K values reported by Drickamer and Bradford,[2] except for temperatures below 140 F. Below 140 F, K values obtained in this investigation are considerably lower than those obtained by the method used by Drickamer and Bradford. This investigation also gives K over a greater range of temperatures and pressures than was previously covered.

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FIGURE 1
This tank, protected by magnesium anodes, is in perfect condition after three years' service.

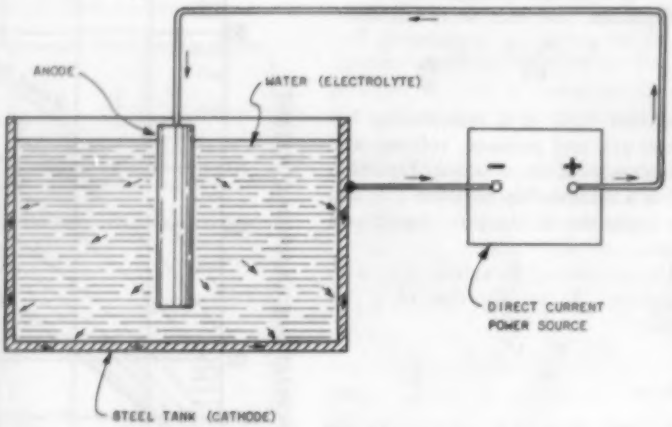

FIGURE 2
Here's an elementary diagram of cathodic protection installation applied to interior surface of tank.

Protect Steel Tanks from Corrosion

You can virtually eliminate corrosion by:

- **Insulating metal through application of protective coating to surface.**
- **Applying cathodic protection current to surface of submerged metal.**

Harry J. Keeling,
Consulting Engineer,
Los Angeles

THE LIFE of steel storage tanks can be improved considerably by application of effective corrosion protection techniques. The corrosion caused by brackish water and basic water and sediment can be virtually eliminated. Here is a review of measures for effectively controlling this type of corrosion.

Since galvanic corrosion on a metal surface immersed in water is accompanied by an electric current flow from the metal into the water, pitting or rusting can be reduced or completely eliminated by suppressing this current flow. There are at least two general methods of accomplishing this:

- By insulating the metal surface from the water through the application of a protective coating to the surface of the tank. (Paints or coal tar coatings depend upon this principle for their success).
- By application of a cathodic protection current to the surface of the submerged metal to maintain it at a negative potential with respect to the water. The existing corrosion-causing voltages are thus neutralized, thereby preventing current flow from the metal into the water.

When a submerged steel surface is receiving cathodic protection, a protective film of hydrogen is formed at the surface of the metal, and this film is constantly renewed by keeping the metal surface charged cathodically with respect to the water. To maintain this charge, it is necessary to provide an external source of direct current electric power.

The magnitude of the current required is dependent upon the specific resistivity of the water, the amount of exposed area of metal and the resistance of the film of paint, oxide, grease, etc., on the surface of the metal.

Figure 2 shows an elementary diagram of a cathodic protection installation applied to the interior surface of a tank. The metal tank is the cathode since it is connected to the negative pole of the direct current source. The current flows into the water by leaving the surface of the anode, which is suspended in the liquid and is connected to the positive terminal of the power source. The choice of material for the anode will be discussed later.

Power Sources

The current required for a cathodic protection installation can be supplied by any convenient source of direct current energy and this choice is usually dictated by economic considerations. Rectifiers have been frequently used where commercial power is available. Galvanic or sacrificial anodes

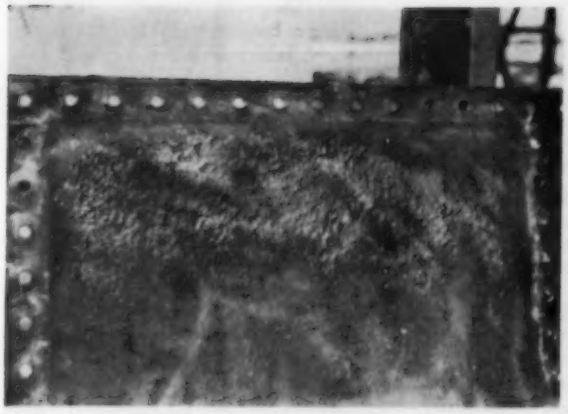

Figure 3. Close-up of plate removed from three-ring wash tank, similar to that in Figure 1. This gives indication of amount of corrosion which takes place in two years where cathodic protection is not used.

Figure 4. Anodes removed from wash tank shown in Figure 1. They had been in service 122 days. Compare new 16-pound anode in center of group. These anodes were used to give cathodic protection to tank walls and steam coils.

are probably the best source of electrical energy where commercial power is not available. Each of these basic sources of electrical energy has its advantages under certain conditions.

RECTIFIERS. Many cathodic protection installations employ the dry disc or plate type rectifier which converts the usual alternating current commercial power to a direct current. These rectifier plates may consist of copper in contact with copper oxide, copper sulfide in contact with magnesium, or selenium in contact with iron. The complete rectifier unit usually comprises a transformer to reduce the voltage from 230 or 115 volts to 20 volts or less, with tap-changing links or rheostats to adjust the voltage, and with fuses or circuit breakers to protect the equipment from overload.

There are numerous modifications to this basic design, to suit local conditions. For instance, in some cases, forced draft ventilation of the rectifier stacks is used in order to reduce the overall physical size of the unit. Oil-immersion of either the rectifier stacks or the complete unit may be used to prevent atmospheric corrosion of the parts where the installation is subject to severe fog or mist. The use of hot-cathode tube type rectifiers in place of the plate type rectifiers may in some cases result in lower original cost where high voltage is required.

Although motor generators have been used as a source of direct current for cathodic protection stations, this source of power is less popular because of the higher maintenance cost due to the moving parts.

GALVANIC ANODES. Referring again to Figure 2, if the material selected for the anode is magnesium or zinc, the external source of direct power can be eliminated in cases where the total circuit resistance is not too high. The magnesium anode rod and the steel tank constitute a galvanic cell in which the magnesium is the anode, the interior steel surface of the tank is the cathode, and the water is the electrolyte. Since magnesium has a higher solution potential than the iron, a driving force of approximately one volt is obtained from this combination, and the necessary cathodic protection current flows through the circuit. In installations of this type, the magnesium anodes are gradually dissolved at a rate proportional to the current flowing. It requires approximately 18 pounds of magnesium to deliver a current of one ampere for one year. The number of magnesium or zinc anode rods required to protect a tank depends again upon the composition of the water, the coating on the surface of the tank, agitation of the water, etc. Because of the low voltage available, however, it will usually require considerably more galvanic anodes to protect a tank than if an external source of direct current is used. Increasing the number of anodes in a tank lowers the total circuit resistance and provides increased current density at the surface of the steel.

Since the anode attached to the positive pole of the direct current power source shown in Figure 2 is discharging current into the water, it will be subject to anodic corrosion and therefore gradually dissolve away. The rate at which the anode is corroded will depend upon the type of material used, the current flowing and the composition of the dissolved materials in the water. Since it would be very desirable to eliminate the anode replacement costs, considerable effort has been spent in developing "permanent" anodes which will either be dissolved at extremely slow rates or preferably not dissolved at all by the action of the cathodic protection current. The list of materials that have been used for anodes in tank installations is quite lengthy. Only the most common materials in use today will be discussed briefly.

PLATINUM. Platinum wires have been used successfully as "permanent" anodes for tank protection and have the advantages of light weight and long life. Generally speaking, platinum anodes are inert and are not subject to corrosion. There have been a few exceptional cases reported where platinum anodes were dissolved through the action of the current flowing from them, but these were unusual and abnormal cases. The chief disadvantage of using platinum is its high cost. To minimize the weight of material required, platinum anodes are usually constructed in the form of thin wires which are suspended vertically in the tank. The small physical size of the platinum anodes results in higher circuit resistance, making it necessary to use somewhat higher applied voltage than if other materials were used. Platinum anodes are rather fragile and the wires are easily lost if they become detached from the holders. Platinum anodes tend to increase the corrosivity of the water through raising the dissolved oxygen content.

CARBON. Carbon or graphite anodes have been used in some applications because here again is a material that is not readily attacked by anodic corrosion. Unfortunately, carbon anodes cannot be considered as "permanent" because experience has shown that in many waters they disintegrate rapidly

through the combined action of the current flowing and the gases or salts dissolved in the water. Other disadvantages to the use of carbon or graphite anodes are high original cost, weight and difficulty in obtaining sufficient mechanical strength. Carbon or graphite anodes also introduce a back electromotive force into the circuit which makes it necessary to increase the rectifier voltage by approximately one volt.

IRON. The iron anodes have the advantage that they are usually readily available from the scrap heap, are mechanically strong and easily replaced. First cost is low, particularly if scrap steel pipe is available. The disadvantages, however, usually outweigh the above advantages and make it desirable to select other materials for tank anodes. Iron anodes are dissolved at the rate of approximately 20 pounds per year for every ampere that is discharged. At $80 per ton for iron scrap, this amounts to about $1.15 per ampere per year for material, allowing for 70 percent utilization efficiency. As the iron anodes are rusted away, the corrosion products fall into the water and may cause discoloration. Since anodes made of iron or any of the other metals that are dissolved have to be replaced more frequently than the platinum anodes, the replacement cost is an important item. If attempt is made to increase the period between replacements by providing additional anode material, the weight of the anodes introduces severe structural problems. Most tank roofs are designed to withstand the normal load from wind, snow, etc., with very little provision for additional dead load. Since the anodes are usually suspended from the roof of the tank, consideration must be given to the total weight of the anodes because of the additional load imposed on the roof. In the older tanks, the cost of reinforcing the roof may make it impractical to use iron anodes heavy enough to provide a reasonable life.

ALUMINUM. Aluminum anodes have been popular during recent years because they offer the advantage of light weight and the corrosion products adhere to the anode. The material is easy to handle or replace, and is not as fragile as either the platinum or the graphite anodes. An inherent advantage of aluminum over other materials for anodes is its low electrochemical equivalent. Aluminum anodes are dissolved at the rate of approximately eight pounds per year per ampere of current flowing. Outweighing these advantages is the fairly high initial cost of aluminum metal, which amounts to approximately $3.80 per year per ampere of current.

MAGNESIUM. As previously indicated, magnesium can be used as a galvanic anode without applying voltage to the circuit from external power source. In recent years, however, magnesium has frequently been used in tank installations with current supplied from an external source. Although the first cost of magnesium is greater than for aluminum, this is balanced by certain advantages inherent to magnesium that are not shared by aluminum. Magnesium is light in weight and therefore introduces very little structural load to the roof of the tank; it is mechanically strong and easily replaced; it contributes approximately one volt emf. to the circuit, and the corrosion products adhere to the anode. Magnesium anodes are dissipated in water at the rate of about 18 pounds per year per ampere of current. This amounts to between $10 and $13 per year per ampere of current.

Magnesium has an additional advantage over other types of anodes, which tends to offset its high original cost. After a cathodic protection system has been in operation for some time on a steel tank, it will be noticed that the bare portions of the steel become covered with a white coating of salts precipitated from the water. This white deposit contributes to the protection received by the steel surface by materially increasing the circuit resistance and reducing the current density required for protection. The type of scale produced will depend on the chemical salts present in the water. In general, where the waters contain large quantities of magnesium in solution, a hard, dense, permanent scale will be produced. The use of magnesium anodes results in the formation of durable protective scales of this type even in waters low in magnesium content. By comparison, the scale formed in tanks using aluminum anodes is fragile and more easily brushed from the surface of the steel through mechanical agitation of the fluid.

Advantages of Cathodic Protection

The inherent advantage of cathodic protection over the use of paints or protective coatings alone for tank interiors, lies in the fact that the cathodic protection system provides a "self-healing" protective film over the exposed surface of the submerged metal. If for any reason the protective coating is disturbed or broken, no damage will take place, because in a short time the cathodic current will build up a new protective film and eventually cover the bare spot with a scale of salts deposited from the water. The use of cathodic protection, therefore, is particularly advantageous in reducing corrosion rates on moving mechanisms. It is very difficult to maintain such protective coatings where one metallic surface scrapes across another. In such cases, the cathodic protection will prevent corrosion on the bare spots where protective coating is broken or worn away.

Another advantage of cathodic protection is the fact that it can be applied to a structure where the paint or protective coating has failed. Whereas in most cases the cathodic protection equipment can be installed without taking the tank out of service, reconditioning of coating or repainting the tank can only be done after it has been drained. This is an important factor where corrosion is taking place in steel tanks, and it is not possible to remove them from service long enough to replace the coating.

Decision as to whether to use cathodic protection alone or in conjunction with the protective coating rests on the enonomic considerations involved. Each individual case should be judged on its own merits. Where labor costs for coating applications are excessive, consideration should be given to the use of a medium-priced protective coating supplemented by the use of cathodic protection as "insurance" to take care of holidays that may develop, or to provide protection after the coating has ultimately failed. When applying cathodic protection to a completely bare tank, the usual procedure is to apply heavy polarizing current for the first few days or weeks, until a deposit of scale is built up on the surface of the metal. Maintenance of protection after the scale has once been built up requires much less current, which can be supplied by a smaller power source or even galvanic anodes.

In certain engineering applications involving corrosive water where the tank is required to be in service for a limited period of time, perhaps only one or two years, it may be advantageous to use cathodic protection on the bare tank since the high operating cost is offset by the high salvage value of the cathodic protection equipment. On the other hand, if the tank is to be protected from corrosion by means of a coating alone, it is difficult to recover the cost of this coating when the tank is retired or moved. ##

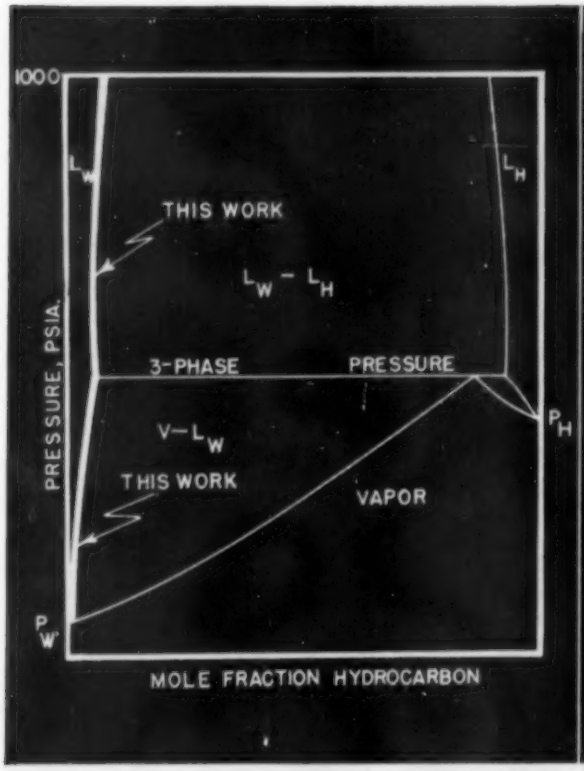

Figure 1. Schematic pressure-composition diagram indicating the region of this investigation.

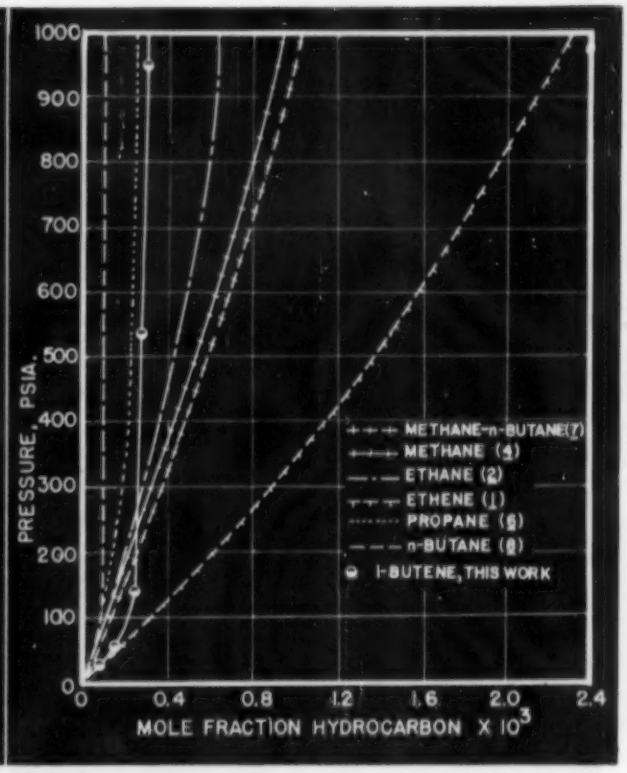

Figure 4. Comparative solubilities of light hydrocarbons in water at 160 F.

The Solubility of 1-Butene in Water

The solubility is as much as four times the solubility of n-butane in water. These data at pressures up to 1000 psia form the basis of a study of the separation of the butane-butene systems by means of water.

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Texas Petroleum Research Committee and Department of Chemical Engineering, University of Texas, Austin

AN EXPERIMENTAL study was made to determine the solubility of 1-butene in water at pressures to 1000 psia and temperatures up to the critical temperature of 1-butene, 291 F. The purpose of this study was to obtain data to compare with those of the solubility of *n*-butane in water.[8] These data will be of value in the design of process units for the separation of *n*-butane-butene mixtures.[9]

A schematic diagram of the general hydrocarbon-water system is shown in Figure 1. The equilibrium water-rich liquid phases studied in this investigation are shown by the heavy solid lines. The experimental data are presented in Table 1.

The 1-butene used in this work was certified to have a minimum purity of 99.0 mole percent. The experimental equipment and the analytical technique were discussed in an earlier article.[2]

The pressure-composition diagram for 100 F. is shown in Figure 2. In the same figure the data for the *n*-butane-water system of Reamer, Sage and Lacey[8] are shown. The break in the curve occurs at the three-phase pressure for the respective system at this temperature of 100 F. Similar breaks will occur at all isotherms up to the three-phase critical temperature. The curves at pressures below the break point represent equilibria between the water-rich liquid phase and the vapor phase. The curves at pressures above the break point represent equilibria between the water-rich liquid phase and the 1-butene-rich liquid phase. All of the experimental data were plotted in similar isotherms for purposes of smoothing the experimental data. The smooth data are shown in Table 2.

In Figure 3 are shown the smoothed values for the solubility of 1-butene as a function of temperature. Above 150

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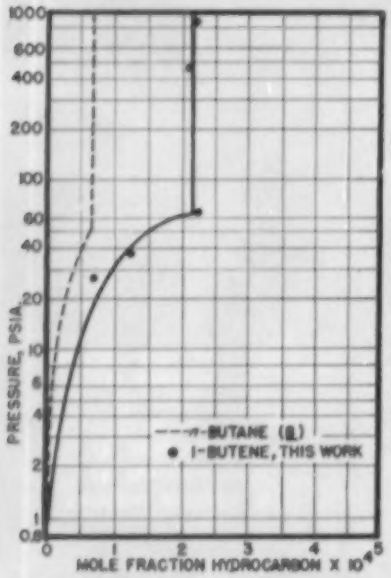

Figure 2. Comparative solubilities of 1-butene and of n-butane in water at 100 F.

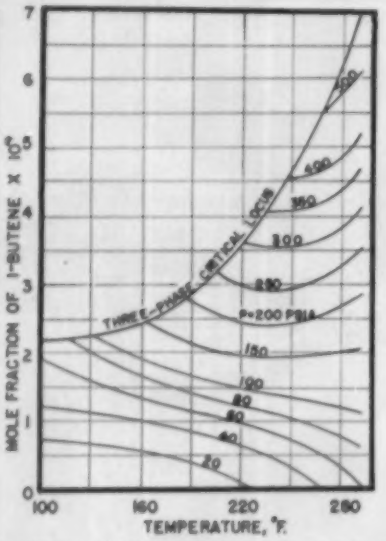

Figure 3. Solubility of 1-butene in water up to the three-phase critical locus.

psia in Figure 3, the solubility passes through minima with an increasing solubility with increasing temperatures. The same phenomena were observed in the methane-water[4,5] and the ethane-water[2,3] systems.

For comparative purposes, the solubilities of several light hydrocarbons in water at 160 F. have been plotted in Figure 4. These data include the solubility of methane-*n*-butane mixtures,[7] methane,[2] ethane,[2,3] ethene,[1] propane,[6] *n*-butane,[8] and 1-butene from the present investigation in the respective hydrocarbon-water systems. These curves show two trends: (a) the decrease in solubility with the increase in molecular weight, both for the paraffin hydrocarbon-water systems and for the olefin-water systems, and (b) the increased solubility of the olefins in water compared to the corresponding paraffin hydrocarbons in water. The breaks in the curves for propane, *n*-butane and 1-butene occur at their respective three-phase pressures. ##

ACKNOWLEDGMENT

The 1-butene used in this work was furnished by the Phillips Petroleum Company.

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TABLE 1. Experimental Values for the Composition of the Water-Rich Phase in the 1-Butene-Water System

Pressure Psia.	Mole Fraction x10⁴ C_4H_8	Pressure Psia.	Mole Fraction x10⁴ C_4H_8	Pressure Psia.	Mole Fraction x10⁴ C_4H_8	Pressure Psia.	Mole Fraction x10⁴ C_4H_8	Pressure Psia.	Mole Fraction x10⁴ C_4H_8
TEMPERATURE = 100 F.		TEMPERATURE = 160 F.		TEMPERATURE = 220 F.		TEMPERATURE = 280 F.		TEMPERATURE = 291.2 F.	
26.6	0.669	26.7	0.785	119.2	1.578	114.8	1.480	139.0	1.865
35.9	1.247	55.5	1.263	207.0	3.096	117.4	1.370	333.0	4.560
63.2	2.214	146.5	2.421	301.0	3.774	285.5	3.817	624.0	7.276
464.5	2.067	534.5	2.726	302.0	3.544	559.0	6.147	752.0	6.942
867.0	2.200	954.0	2.939	573.0	4.760	726.0	6.386	931.0	6.804
				931.0	5.062	986.0	6.487		
						990.0	6.592		

TABLE 2. Smoothed Values for the Composition of the Water-Rich Liquid Phase

Pressure (psia)	Mole Fraction 1-Butene x 10⁴	Pressure (psia)	Mole Fraction 1-Butene x 10⁴	Pressure (psia)	Mole Fraction 1-Butene x 10⁴	Pressure (psia)	Mole Fraction 1-Butene x 10⁴	Pressure (psia)	Mole Fraction 1-Butene x 10⁴
TEMPERATURE = 100 F.		TEMPERATURE = 160 F.		TEMPERATURE = 220 F.		TEMPERATURE = 280 F.		TEMPERATURE = 291.2 F.	
10	0.42	10	0.24	20	0.10	60	0.30	60	0.04
20	0.68	20	0.57	40	0.60	80	0.77	80	0.61
40	1.19	40	1.00	60	0.94	100	1.16	100	1.00
60	1.89	60	1.35	80	1.20	150	2.00	150	2.04
*63.2	2.17	80	1.64	100	1.45	200	2.67	200	2.84
80	2.17	100	1.91	150	1.96	250	3.26	250	3.53
100	2.17	*146.5	2.42	200	2.43	300	3.80	300	4.14
200	2.17	200	2.52	250	2.97	350	4.32	350	4.70
300	2.18	300	2.62	300	3.52	400	4.82	400	5.18
400	2.18	400	2.70	*301	3.64	500	5.78	500	6.09
500	2.18	500	2.75	400	4.06	*561	6.15	600	6.87
600	2.18	600	2.79	500	4.40	600	6.22	*624	6.96
700	2.18	700	2.83	600	4.67	700	6.32	700	6.96
800	2.18	800	2.86	700	4.90	800	6.41	800	6.96
900	2.18	900	2.89	800	5.10	900	6.49	900	6.96
1000	2.18	1000	2.92	900	5.27	1000	6.57	1000	6.96
				1000	5.42				

* Three-phase critical pressure

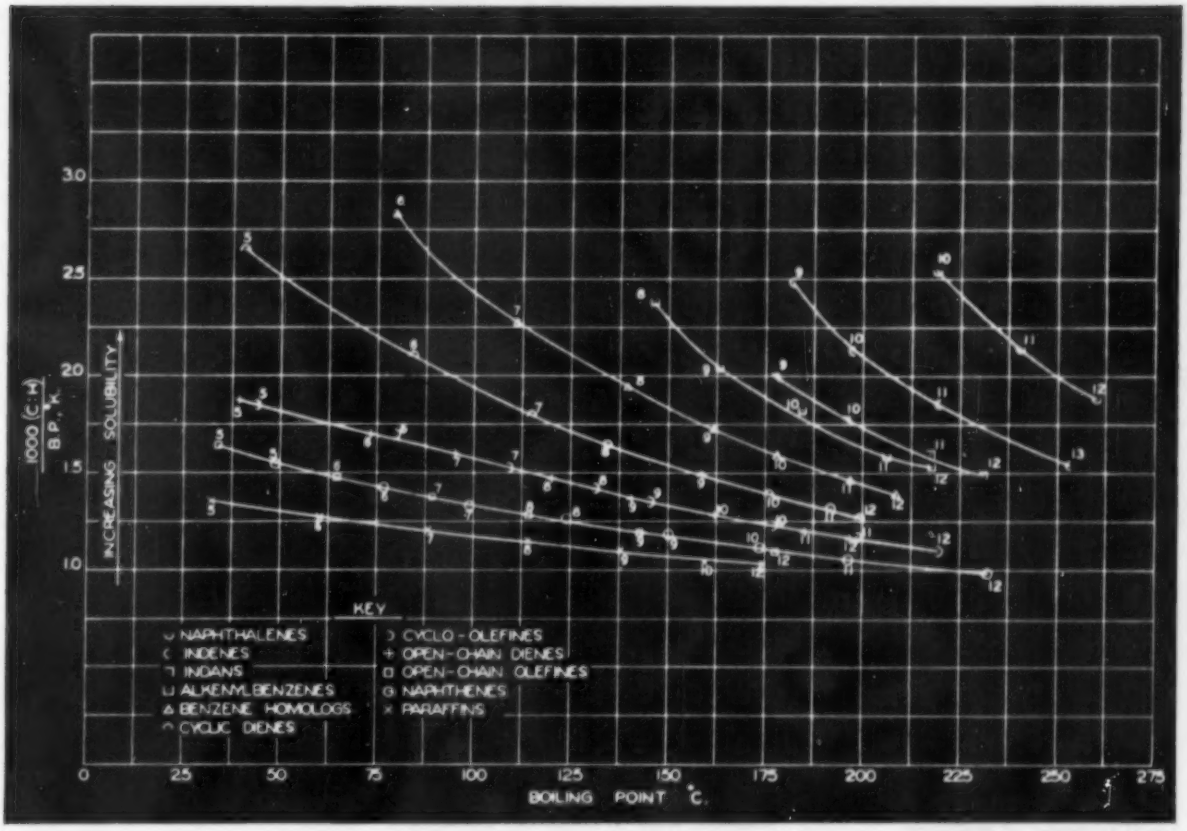

Figure 1. The relationship of boiling point to the C:H/B.P. ratio for various classes of hydrocarbons shows the overlap in solubility. This is a complicating factor in the extraction process.

Pure Aromatics From Cracked Naphthas

Nitration-grade aromatics can be recovered from unsaturated cracked naphthas. Here are test results describing the techniques used and the yields and purities obtained.

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THE UDEX EXTRACTION process has been utilized for the recovery of benzene, toluene, and xylenes (B-T-X) only from saturated concentrates. These, in turn, have been mainly obtained from Platforming and other catalytic reforming operations, although in one case[1] an unsaturated feed has been prepared for Udex extraction by Platreating. Here is a description of the application of the Udex process to recovery of aromatic extracts directly from unsaturated naphthas of various sources and types.

The extraction, on an experimental laboratory unit, of six cracked aromatic concentrates is described. Five of the stocks were in the B-T-X range, and the sixth contained principally 9- and 10-carbon aromatics. All contained large amounts of mono-olefins, but they varied in their content of conjugated dienes and alkenyl-aromatics.

Results indicate that direct Udex extraction and subsequent clay treat-

ing yield aromatics of nitration grade only if the conjugated diene and alkenyl-aromatic content of the feed are low. If the latter are high but the former low, the extraction must be preceded or followed by selective hydrogenation, and the extract must be clay treated. If the diene content is high, selective prehydrogenation of the feed is necessary if extraction and clay treating are to produce nitration-grade aromatics.

The application of the Udex process to the extraction of thermally and catalytically cracked naphthas could increase the potential U. S. production of light aromatic hydrocarbons approximately ten-fold.

As has been previously described,[2] the Udex process, which was originated by The Dow Chemical Company and commercially developed by Universal Oil Products Company, is a liquid-liquid countercurrent extraction employing aqueous diethylene glycol as solvent. As applied to saturated light aromatic concentrates, it is characterized by high aromatic recovery, extreme purity of the extract, and unusual economy of operation.

Since the Udex solvent exhibits a selectivity roughly proportional to the carbon/hydrogen ratio of the feed components and inversely proportional to their boiling point, it is to be expected that, for hydrocarbons of approximately equal boiling point, the several hydrocarbon types present in cracked naphthas will be absorbed in the following order: alkenylbenzenes, benzenoid aromatics, cyclic dienes, open chain dienes and cyclic olefins, open chain olefins and cycloparaffins, and paraffins. For wide-boiling fractions, the extraction is complicated by the fact that the higher homologues of one type overlap in solubility the lower homologues of other types lower in carbon/hydrogen ratio. This relationship is illustrated qualitatively in Figure 1, in which the quotient of the carbon/hydrogen ratio and the boiling point is plotted versus the boiling point for several series of hydrocarbons of 5 to 12 carbon atoms.

It is clear from these considerations that the recovery of pure aromatics from any particular cracked stock must depend upon the width of the boiling range, the types of unsaturated compounds present, their amount, and the ability of conventional finishing operation to remove residual amounts of these materials left in the extract.

Charge Stocks—To illustrate the behavior of various types of cracked feed available, six commercial samples were subjected to bench scale extraction. These stocks, the properties of which are shown in Table 1, are believed to be of the following origin:

Stocks A and B were B-T-X fractions of aromatic concentrates remaining after removal of most of the dienes and alkenyl aromatics and some mono-olefins, as in the manufacture of petroleum resins, from the products of high-temperature pyrolysis operations.

Stocks C, D, and E were fractions of the raw products from high-severity thermal cracking operations designed to make light olefinic gases and aromatics. It will be noted that C and D contain considerably more conjugated dienes than A and B. The three stocks of this type differ from each other principally in boiling range—C is essentially a B-T cut and D a B-T-X fraction, while E comprises mainly 9- and 10-carbon aromatics.

Stock F is a light oil recovered from the absorber used to scrub gas from an oil-gas cracking unit.

Apparatus—The small bench scale extraction plant utilized in this work was designed to operate with hydrocarbon feed rates of around 100 ml. per hour. The extractor was a packed column of the type described by Reed and Fenske.[5]

A flow diagram of the process is shown in Figure 2. Fresh feed enters the center of the extraction column, and recycle stock from the stripper overhead (together with light paraffins when employed) enters near the bottom. These flow upward, and the raffinate product is taken from the top. Lean solvent enters near the top of the extractor and flows downward and the rich solvent is withdrawn from the bottom and discharged near the top of the stripper. The latter operates at about atmospheric pressure while the extraction column is maintained at an elevated pressure.

The overhead from the stripper, after removal of water, is recycled to the extractor, while the aromatic product and water are taken off as a side cut. The lean solvent in the reboiler, where the water content is controlled by a recirculating water stream, is pumped back to the top of the extractor. The water streams separated from the stripper overhead and side cut are combined and recycled to the reboiler.

Steel construction is used throughout except for chargers, receivers, stripper and reboiler which operate at near atmospheric pressure. These latter are made of glass.

The pressure on the extractor is controlled by introducing a small stream of nitrogen into the top of the extractor and venting through a pressure controller. The small cushion of nitrogen maintained at the top of the extractor minimizes the effect of pump surging.

The feed rate, water recycle rate and light paraffin reflux rate are measured by charger readings. The lean solvent rate and overhead recycle rate are determined by flowmeters.

TABLE 1
Properties of Feed Stocks

Stock	A	B	C	D	E	E (Unifined)	F	F (Unifined)
Density, d_4^{20}	0.8600	0.8309	0.8302	0.8174	0.8587	0.8560	0.8558	0.8585
ASTM Distillation (D86-52)								
I.B.P., °F	131*	175*	176	163	317	.....	138	153
10 Percent Over	171*	177*	179	200	322	.....	181	188
50 Percent	219*	233*	184	238	329	.....	210	211
90 Percent	280*	287*	216	284	344	.....	264	272
End Point	302*	302*	350	332	378	.....	320	.....
Type Analysis, Wt. %								
Aromatics	79.6	78.4	66.3	58.3	85.3†	86.5†	86.4	85.1
Benzene	20.4	18.6	48.0	14.2	.....	.....	41.5	39.4
Toluene	37.3	35.3	16.8	18.5	.....	.....	36.1	35.5
Xylenes	21.8	26.8	1.5	23.1	.....	.....	5.8	7.6
Alkenylaromatics			.....	2.5	8	.....	3.0	0
Olefins (Non-aromatic)	20.4	21.6	.....	.....	1.0†	0.6†	.....	.....
Paraffins, Naphthenes			.....	.....	13.7†	12.9†	.....	.....
Bromine No.	28.3	37.3	40	41.7	12.2	0.6	34.8	1.2
Diene No.	0.95	0.96	15.7	8.4	0.5	.....	17.5	.....
Sulfur, Weight Percent	0.05	0.03	0.08	0.07	0.04	0.0019	0.37	0.0082
Nitrogen, Weight Percent	.....	0.01	.....	0.0001	<0.01	.....	<0.01	<0.0001
Kauri Butanol Value	.....	.....	.....	.....	81.9	.....	.....	.....

* Precision Distillation. † Fluorescent Indicator Analysis.

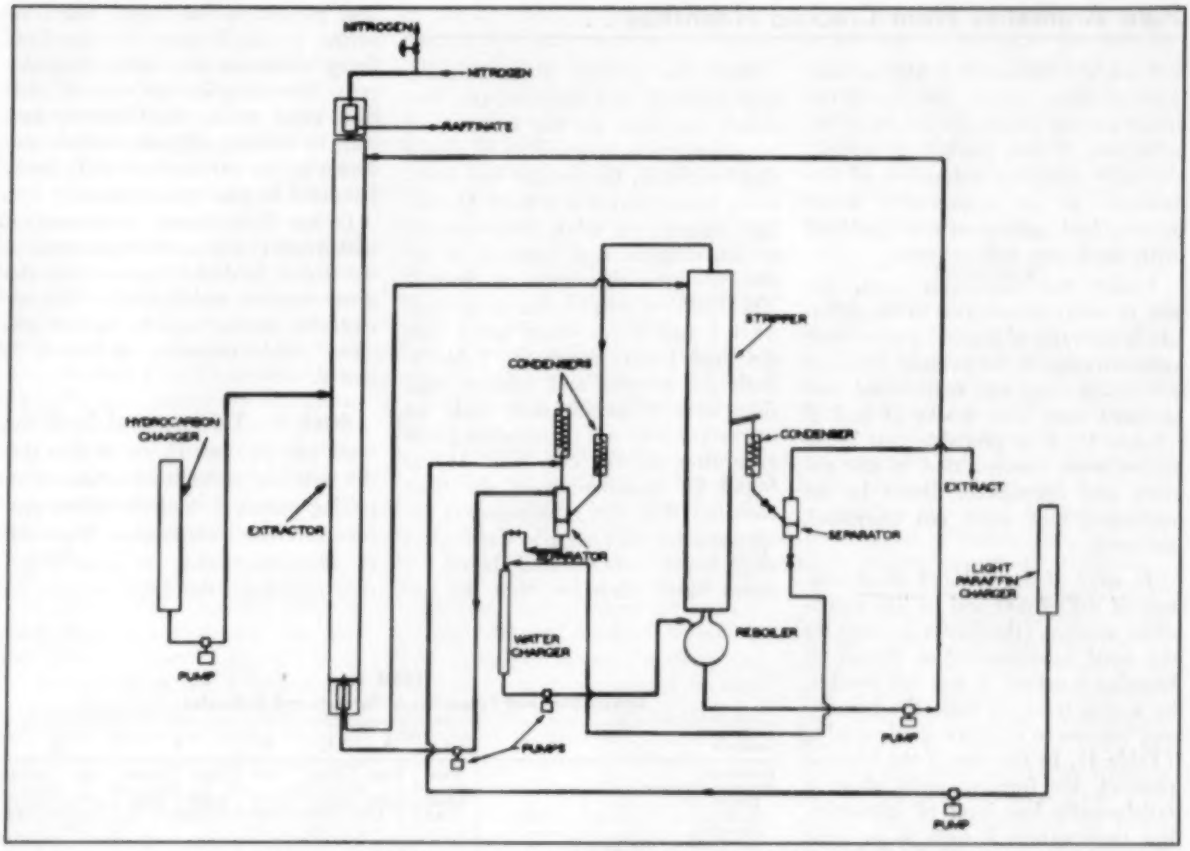

Figure 2. Simplified flowsheet of the experimental apparatus used in these tests.

All of the preheaters, extractor column, stripper column and reboiler heaters are manually controlled through variable transformers.

The extractor column by calibration with a pure n-hexane-methyl cyclopentane-benzene mixture, was found to contain 13 theoretical stages.

Discussion of Results—The yields and recoveries are shown in Table 2. Table 3 summarizes the properties and composition of the extracts and raffinates, and Table 4 those of the benzene, toluene, and xylene fractions derived from the extracts.

Stocks A and B—No difficulty was experienced in extracting from these feeds, which have a low diene content and virtually no styrene, B-T-X concentrates which, after clay-treat, caustic wash, and re-running, yielded nitration-grade benzene, toluene, and xylene fractions. It will be noted (Table 2) that under the conditions used the recovery of benzene is almost quantitative, that of toluene about 80-90 percent, and of xylenes-ethylbenzene a little under 50 percent. Such decreasing yields of higher homologs are to be expected from the solubility relationships shown in Figure 1. Yields of toluene and xylenes could be increased, however, by operating at more severe extraction conditions.

The extraction of these feeds resulted in concentration of the olefins in the raffinates. Nevertheless, the bromine numbers of the extracts are considerably higher than those of similar extracts derived from the usual commercial feedstocks. Although these residual olefins are polymerized in the clay treater so that they do not interfere with the recovery of nitration-grade aromatics, it is probable that a relatively short clay-life would be experienced with such extracts. The olefin content of the raw extract could undoubtedly be further reduced, however, by extraction under more severe conditions.

Stock C—This feed differs from the previous two in that, first, it is largely a benzene-toluene concentrate, low in

TABLE 2
Extraction Yields

Feed Stock	A	B	C	D	E		F	
Pretreatment	None	None	None	None	None	Unifined	None	Unifined
Light Paraffin, v/v of fresh feed	0.083	0.074	0	0	0	0	0	0.048
Recovery and Yields								
Extract—Wt. % of Hydrocarbon Feed	62.7	55.6	67.2	55.6	78.2	71.8	70.6	64.0
% Aromatic Recovery	79	72	97	91	92	83	.....	74
Raffinate—Wt. % of Hydrocarbon Feed†	33.3	40.2	32.4	41.6	.....	28.2	27.4	24.6
% Aromatic Recovery	22	20	10	8	.....	4	.....	20
Unaccounted Loss—Wt. % of Hydrocarbon Feed	4.0	4.2	0.4	2.8	.....	0	2.0	11.4
% Aromatic Loss	−1	8	−7	1	.....	13	.....	6
Yield of Extracted Aromatics, Percent								
Benzene	99	96	109	96	.....	.....	.....	(94)* 90
Toluene	89	79	65	87	.....	.....	.....	(69) 67
Xylenes	45	48	63	87	.....	.....	.....	(25) 33

* Figures in parenthesis based upon corresponding aromatic hydrocarbon in Unifined feed to Udex; other figure based on aromatic in feed to Unifiner.
† Does not include light paraffin (n-hexane).

xylenes, and second, it is high in conjugated diene content. Because of the lower average molecular weight of the aromatics, it was possible to achieve virtually complete extraction of the benzene at an appreciably lower solvent/feed ratio than was employed with the higher-boiling feeds.

Under the conditions used, the dienes were concentrated in the raffinate in the ratio of about 3:1 over their concentration in the extract. This approximate ratio was maintained also in later runs with stocks D and F (Table 3). It is probable that cyclic dienes were concentrated in the extract and open-chain dienes in the raffinate; they were not identified, however.

In spite of the reduced diene content of the extract and its low monoolefin content (the dienes account for the total unsaturation as shown by bromine number) it was not possible, by a clay treat, to raise the benzene and toluene to nitration-grade quality (Table 4). In the case of the benzene product, the freezing point shows a satisfactorily low level of impurities, but their nature is such as to cause high acid wash color values. It has been shown[3] that only 0.002 percent of cyclopentadiene may be tolerated in nitration-grade benzene; larger amounts cause an off-specification acid-wash color. A second clay treat (not shown in the tables) did not markedly improve the product.

It is evident that presaturation of the olefins and dienes will permit recovery of nitration-grade aromatics from this stock. Such an operation has been successfully carried out commercially with such a stock, using the Platreating process for prehydrogenation.[1]

Stock D—This feed is characterized by the presence of both conjugated dienes and styrene, the former in lesser quantities than were present in Stock C, the latter in the amount of about 2.5 percent (Table 1). It was extracted under substantially the same conditions as the other B-T-X feeds, with good recovery of all the aromatic components (Table 2). The styrene was quantitatively transferred to the extract, while, as in the case of Stock C, the raffinate was approximately three times as concentrated in dienes as the extract.

Since the content of unsaturates, both aromatic and non-aromatic, was clearly too high for the recovery of nitration-grade aromatics by direct clay-treatment, the extract was selectively hydrogenated in a batch Unifining[4] operation with cobalt-molybdenum-alumina type catalyst, to reduce the bromine number to about 1. The Unifined extract was then clay-treated and re-run three times with the final results shown in Table 4. Both the benzene and toluene fractions were off-specification, while the xylene fraction was of nitration-grade even after the first clay treat. It was found by examination of the forerunnings that the components responsible for the poor acid wash colors were largely concentrated therein. It seems likely, therefore, that the styrene present in the extract was converted to ethylbenzene in the Unifining treatment to a satisfactory degree. However, in the case of this high diene stock, the Unifining and clay treatments did not reduce the dienes in the extract to a sufficiently low level to pass specifications.

It has been noted in connection with Stock C that prehydrogenation of the Udex feedstock can reduce the diene content satisfactorily. This alternative method will be further discussed with reference to Stocks E and F.

Stock E—This material is of the same type as Stock D, except that it is the next higher-boiling fraction, comprising mainly 9- and 10-carbon aromatics. These include about 8 percent of alkenylaromatics, presumably styrene homologs; the diene content, on

TABLE 3
Composition and Properties of Extracts and Raffinates

Feedstock	A	B	C	D	E		F	
Pretreatment	None	None	None	None	None	Unifined	None	Unifined
Properties of Extract								
Density, d_4^{20}	0.8682	0.8694	0.8766	0.8727	0.8839	0.8769	0.8714	0.8726
Br. No.	4.0	2.7	10.0	19.8	15.3	.....	18.1	0.2
Diene No.	.....	.....	8.0	[c]1.8	.....	.....	7.0	.....
Kauri Butanol Value	.....	.....	.....	.....	[f]100.6	97.3	.....	.....
Composition of Extract, Weight Percent								
Total Aromatics	.....	.....	.....	.....	99.9	[a]99.6	.....	.....
Benzenes	32	27	78.0	24.5	.....	.....	.....	58
Toluenes	53	50	16.2	29.0	.....	.....	.....	38
Xylenes	15	23	1.4	36.2	.....	4	.....	3
Olefines	[d]2.2	[d]1.5	.....	.....	0.1	0.4	.....	.....
Paraffins, Naphthenes	.....	.....	.....	.....	0	0	.....	.....
Sulfur	.....	0.05	.....	.....	.....	.....	.....	0.0033
Styrene, Alkenylbenzenes	.....	.....	.....	[a]5.3	[d]12	.....	.....	.....
Properties of Raffinate								
Density, d_4^{20}	0.7861	0.7713	0.7747	0.7528	Not	0.7749	0.8445	0.8030
Br. No.	65.7	79	86	56	Analyzed	.....	57	2.8
Diene No.	.....	.....	23	[a]5.0	.....	.....	23.1	.....
Composition of Raffinate								
Total Aromatics	.....	.....	.....	.....	.....	[b]13.0	.....	.....
Benzenes	2	32	6	0.1	.....	.....	.....	53.5
Toluenes	19		14	2.2	.....	.....	.....	
Xylenes	29		.....	7.3	.....	0	.....	
Paraffins, Naphthenes	.....	.....	.....	.....	.....	86.3	.....	.....
Olefines	.....	.....	.....	.....	.....	0.7	.....	.....
n-Hexane	.....	.....	.....	.....	.....	.....	.....	24.2

[a] Includes light paraffins, where used.
[b] By Infrared analysis.
[c] By fluorescent indicator analysis.
[d] From Bromine Number.
[e] By ultra-violet analysis.
[f] Calculated from data on blends.
[g] 21% Ethyl toluenes, 52% Trimethylbenzenes.
[h] 3.4% Ethyltoluenes, 3.4% Trimethylbenzenes.

TABLE 4
Properties of Aromatic Fractions Derived from Udex Extracts

Feedstock	A	B	C	D	F	F
Pretreatment of Feedstock	None	None	None	None	Unifined	Unifined
Treatment of Extract	Clay	Clay	Clay	Batch Unifining, Clay	None	Clay
Benzene Fraction						
Density, d_4^{20}	0.8792	0.8775	.....	0.8787	0.8790	0.8789
Refractive Index, n_D^{20}	1.5009	1.5006	.....	.....	1.5007	1.5007
Acid Wash Color	1—	1—	4	5	7	2—
Solidifying Point, Deg. Cent.	5.49	5.39	5.4	4.3	5.2	5.44
Sulfur, Weight Percent	0.0026	0.0025	.....	.....	.....	0.002
Toluene Fraction						
Density, d_4^{20}	0.8672	0.8666	.....	0.8655	.....	0.8669
Refractive Index, n_D^{20}	1.4968	1.4967	.....	.....	.....	1.4968
Acid Wash Color	1—	1—	7	4	>8	2+
Paraffins, Volume Percent	<0.2	<0.2	.....	0.8	.....	<0.2
Sulfur, Weight Percent	0.0021	0.0024	.....	.....	.....	0.001
Xylene Fraction						
Density, d_4^{20}	0.8674	0.8670	.....	0.8641	.....	0.8671
Acid Wash Color	6+	1+	.....	5	.....	1—
Paraffins, Volume Percent	<0.2	<0.2	.....	0.5	.....	<0.2
Sulfur, Weight Percent	0.0024	0.0027	.....	.....	.....	0.004

the other hand, is relatively low (Table 1).

Because of the lowered solubility of these higher molecular weight aromatic components in the Udex solvent, it was necessary to employ a higher solvent/feed ratio than was used with Stock D (Table 2). Under the conditions employed, however, a satisfactory recovery of aromatics (92 percent) was obtained. The extract was substantially 100 percent aromatic (Table 3), and contained substantially all of the alkenylaromatics present in the feed. That the bromine number (15) was caused by alkenylaromatics was demonstrated by batch Unifining of the extract. The product was reduced in bromine number to 1.6, and showed 99.4 percent aromatics by fluorescent indicator analysis.

As an alternative operation, this same stock was Unifined prior to Udex extraction, reducing the bromine number from 12 to 0.6 (Table 1). Extraction of the Unifined feed at somewhat milder conditions than had been employed with the raw feed (Table 2) yielded an extract containing 83 percent of the aromatics charged, and of somewhat lower olefin content than the product prepared previously by Unifining the unsaturated extract (Table 3). This extract was shown by infrared analysis to contain 4 percent xylenes, 21 percent ethyltoluenes, 11 percent mesitylene, 34 percent pseudocumene, and 7 percent hemimellitene. Its Kauri Butanol value (97.3) compares favorably with that of 2° Toluol (100).

Stock F—This feed, essentially a B-T-X fraction, has a styrene content slightly higher than that of Stock D and a conjugated diene content twice as great (Table 1). In the light of previous experience with such stocks, it was not surprising that Udex extraction of the raw stock produced an extract which, while it was of reduced diene content, was nevertheless far too rich in unsaturates for conversion to nitration grade aromatics by clay treating.

The raw feed was therefore Unifined to a bromine number of 1.2 and the hydrogenated product again subjected to Udex extraction (Table 2); the Unifining operation, as shown by the analyses of Table 1, did not appreciably reduce the aromatic content of the feed. Under the extraction conditions shown, about three-fourths of the aromatics charged were extracted; at slightly more severe extraction conditions, however, 97 percent of the aromatics were recovered in an extract of equal quality (run not shown in table).

Fractionation of the extract without further treatment indicated that the individual aromatic fractions showed excessive acid wash color, although in other respects the benzene met nitration grade specifications. After clay treating however, the benzene, toluene, and xylene fractions were all of nitration grade. (Table 4).

The cracked aromatic concentrates herein discussed have ranged in aromatic content from about 60 percent to about 85 percent. On the other hand, saturated feeds commercially extracted by the Udex process contain from about 50 percent to as little as about 10 percent aromatics. The Udex extraction of thermally and catalytically cracked naphthas to recover light aromatics appears entirely feasible, and would enormously increase our potential for producing such hydrocarbons. At present U. S. refineries produce approximately 1.2 billion barrels of cracked gasoline yearly,[5] of which roughly half is thermally cracked and half catalytically cracked.[6] If we assume[7] an average aromatic content for this gasoline of only 15 percent, of which 60 percent (or 9 percent of the gasoline) comprises benzene, toluene, and xylenes, in an assumed ratio of 1:4:8, recoverable by Udex extraction to the extent of 90, 75 and 60 percent, respectively, we may conservatively estimate our aromatic resources from cracked stocks as shown in the second column of Table 5.

TABLE 5

Aromatic Production and Resources in U.S.
(Millions of Gallons)

	Estimated 1953 Production*	Estimated Availability (1954) by Extraction of Cracked Gasolines†	Estimated 1955 Production from Coal Tar†	Estimated Availability 1955 from Straight-Run and Natural Gasoline‡
Benzene	270	330	201	1270
Toluene	97	1400	42	2520
Xylenes	101	2800	16	3230
Total	468	4550	259	7020

* Based on data in O&GJ, 52, No. 45, 81 (March 15, 1954) and report of U.S. Tariff Commission on "Synthetic Organic Chemicals, Tar and Tar Crudes," June, 1953.

† From Report of President's Materials Policy commission (1952), Vol. IV, p. 170.

‡ By direct recovery and Platforming potential, as estimated ibid, pp. 193-4.

It is apparent that the application of the Udex process to the extraction of cracked naphthas would more than double our benzene potential, and increase toluene and xylene production 14 and 28-fold, respectively, thus making it possible to raise our over-all production of light aromatic hydrocarbons approximately 10-fold and adding materially to our available aromatic resources.

Summary

The direct Udex extraction of highly unsaturated cracked naphthas, followed by a clay treat of the extract, yields aromatics of nitration-grade quality only if the conjugated diene and alkenylaromatic content of the feed are low. If the alkenylaromatic content is high but the diene content low, the direct extraction must be preceded or followed by selective hydrogenation (such as Unifining), and the extract clay-treated, since alkenylaromatics are quantitatively extracted in the Udex operation. On the other hand, if the diene content of the feed is high, selective prehydrogenation of the feed (as by Unifining or Platreating) is necessary if Udex extraction and subsequent clay treating are to produce nitration-grade aromatics. The application of the Udex process to the extraction of thermally and catalytically cracked naphthas would increase the potential U. S. production of light aromatic hydrocarbons approximately 10-fold.

Presented at the September, 1954, meeting of the Petroleum Division of the American Chemical Society, New York City.

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ACKNOWLEDGMENT

The authors wish to acknowledge their indebtedness to The Dow Chemical Company, to Fred Ramquist for assistance in much of the experimental work, to Dr. C. H. Watkins for carrying out the Unifining operations, to E. Baclawski, R. W. Neuzil, and Dr. D. R. Long for the absorption spectral analyses, and to Dr. D. B Broughton for his many helpful suggestions

FOOTNOTES

[1] Petroleum Refiner, 32, No. 5, 142 (1953); Pet. Times, 57, No. 1454, 448 (1953); Pet. Eng., 25, No. 5, C-20-21 (May, 1953).

[2] D. Read, O & GJ, 51, No. 7, 82-89 (June 23, 1952); Petroleum Refiner, 31, No. 5, 97-103 (May, 1952); Chem. Eng., 58, 242-4 (Nov., 1951); ibid, 59, 242-5 (May, 1952); ibid, 60, 346-52 (Nov., 1953); J. C. Reidel, O & GJ, 52, 72-5, 91 (Jan. 4, 1954); F. L. Resen, ibid, 50, 55-6 (March 3, 1952); D. P. Thornton, Jr., Pet. Proc., 8, 384-7 (March, 1953); ibid, 7, 498-501 (April, 1952); World Pet., 23, 38-42 (April, 1952).

[3] C. L. Dunn and G. E. Liedholm, Petroleum Refiner, 31, No. 5, 104-8 (May, 1952).

[4] Grote, Watkins, Poll and Hendricks, Petroleum Refiner, 33, No. 4, 165 (April, 1954).

[5] O & GJ, 52, No. 38, 146 (Jan. 25, 1954).

[6] Moorman, ibid, 52, No. 26, 92 (Nov. 2, 1953).

[7] Calculated from data of H. C. Rampton, J. I. P., 35, 42-60 (1949); A. N. Sachanen, "Chemical Constituents of Petroleum," pp. 260-266 (Reinhold Pub. Corp., New York, 1945); F. D. Rossini et al. "Hydrocarbons from Petroleum," pp. 444-455.

[8] T. M. Reed, III and M. R. Fenske, Ind. Eng. Chem., Vol. 42, 654-660 (1950).

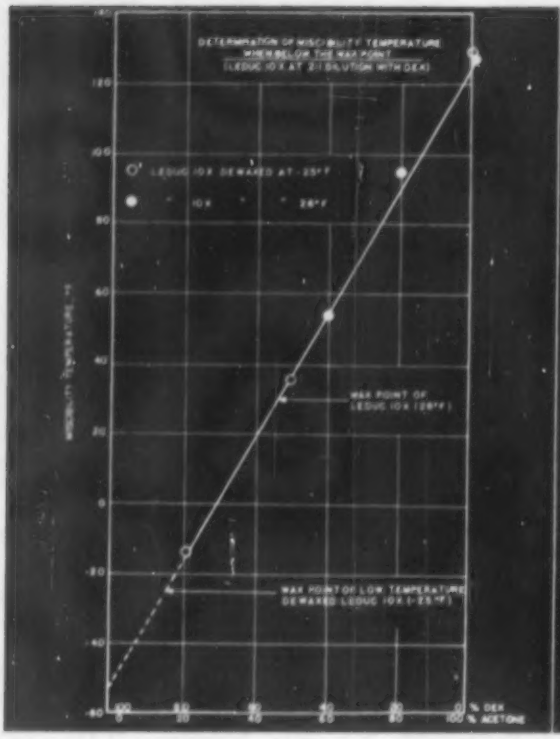
DETERMINATION OF MISCIBILITY TEMPERATURE
WHEN BELOW THE WAX POINT
(LEDUC 10 X AT 2:1 DILUTION WITH DEK)
LEDUC 10X DEWAXED AT -25°F
10X " " 28°F
WAX POINT OF LEDUC 10 X (28°F)
WAX POINT OF LOW TEMPERATURE DEWAXED LEDUC 10 X (-25°F)
% DEK
% ACETONE

Figure 2

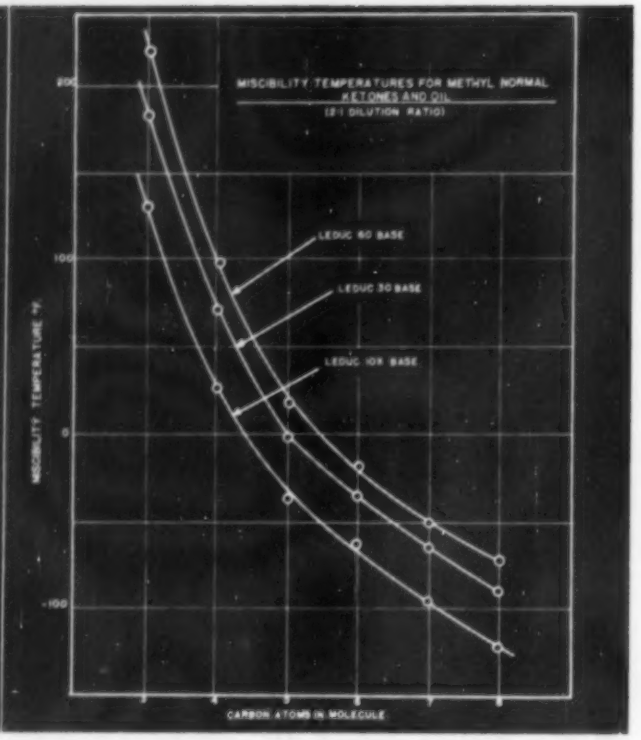

Figure 3

Higher Ketones as Dewaxing Solvents

Some ketones show better performance as dewaxing solvents than MEK-aromatic mixtures. Supporting data from both research and actual plant operations are reported.

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Imperial Oil Limited,
Sarnia, Ontario

HIGHER KETONES have proved unusually satisfactory as dewaxing solvents—so much so that Imperial Oil Limited has recently awarded a contract for the construction of this type plant at its Edmonton refinery. Successful operating experience using a pure ketone solvent (instead of the conventional mixtures of benzene or toluene) has been obtained at their Sarnia refinery during the last 15 years.

The basic laboratory investigations have been previously described by Pokorny and Stratford,[1] while the actual operation of the commercial unit was reported by Meuller.[2]

This article explores the basic considerations involved in solvent selection and reports the results of extensive laboratory evaluations of higher ketones. Comparisons of the dewaxing performance of the higher ketones with that of MEK-aromatic mixtures shows a definite advantage for the former.

In selecting a ketone for use as a dewaxing solvent, three major considerations are oil miscibility, wax solubility and filter rate. A dewaxing solvent must be completely miscible with the oil being dewaxed at the temperatures and dilutions used in the dewaxing process. A good dewaxing solvent should also have the lowest possible solubility for wax, since a solvent of low wax solubility will permit dewaxing at higher temperatures for a given pour point oil with a consequent saving in refrigeration costs. As the precipitated wax must be removed from the oil-ketone solution by filtration, a high filter rate is desirable. Most of the saturated aliphatic ketones meet other requirements such as stability, non-corrosiveness, reasonably low boiling point and low water solubility. Table 1 gives physical properties of the ketones investigated in this study.

Miscibility temperatures of oil-

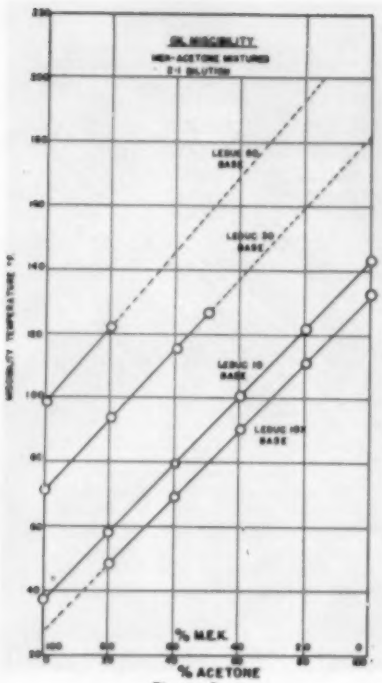


Figure 1

ketone mixtures are readily obtained in cases where an oil phase separates at a temperature above the wax point of the solution. However, when wax separates above the miscibility temperature, the determination is not so simple. In these cases it has been found possible to raise the miscibility temperature above the wax point by the addition of a lower molecular weight ketone. A series of miscibility temperatures obtained in this manner can be extrapolated back to zero concentration of the lower molecular weight ketone to give the required miscibility temperature. To be valid, this method requires that the miscibility temperatures of a given oil-ketone system be a linear function of the percentage of low molecular weight ketone in the solvent. This can be demonstrated over the full range of ketone concentrations in the case of the lower molecular weight ketones where miscibility temperatures occur above the wax point of a dewaxed oil. This is shown in Figure 1, for three different grades of lube oil diluted 2:1 with MEK-acetone mixtures. The application of this technique to determine the miscibility temperature when below the wax point is shown in Figure 2.

Using the technique described above, miscibility temperatures of various ketones with 10, 30 and 60-grade lube oils have been determined at a 2:1 dilution ratio. Inspections on these oils are shown in Table 2 and miscibility data in Table 3. Miscibility temperatures are shown in Figure 3 plotted against the number of carbon atoms per molecule for methyl normal ketones. As would be expected miscibility temperatures fall rapidly with increasing molecular weight. The C_5 ketones (MPK and DEK) are the lowest molecular weight ketones having miscibility temperatures which could permit dewaxing a 10-grade oil at 0°F. or a 60-grade oil at 25 F. Moving the carbonyl group towards the center of the ketone chain lowers the miscibility temperature. Isoketones have miscibility temperatures which are 15 to 20 F. higher than the corresponding normal ketones. As would be expected, heavy oils are less soluble in ketone and have higher miscibility temperatures than oils of lower viscosity. This effect decreases somewhat with increasing molecular weight of ketones.

As will be seen from Figure 4, miscibility temperatures were found to be constant over a fairly wide range

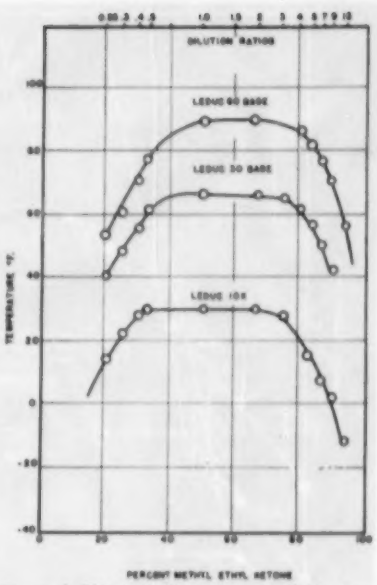


Figure 4. Effect of dilution on miscibility temperature.

of dilution ratios with methyl ethyl ketone. In the case of the 60-grade oil, little or no change in miscibility temperature occurred over the range of 1 to 3 dilution ratios. For the 10-grade oil this region of constant miscibility temperature shifted to between 0.5 to 2.5 dilution ratios. Outside of these ranges at both the higher and lower dilutions miscibility temperatures decreased rapidly. The same effect has been found for diethyl ketone and may be assumed to apply to other members of the series.

The effect of water on miscibility temperatures of oil-ketone solutions can be determined by direct measurement if these temperatures occur above the point of wax separation. A 60-grade oil was selected to evaluate this effect because miscibility temperatures are usually critical and are most easily determined experimentally with a high viscosity lube fraction. To eliminate wax interference, a sample of Leduc 60 base oil was dewaxed to —5/—10 F. pour/solid. The effect of water on the miscibility temperature of 3:1 dilutions with MPK, DEK and MiBK is shown in Figure 5. In each case the first additions of water cause the oil miscibility temperature to rise about 30 F. for each 1 percent water, but at a certain water content the oil miscibility temperature reaches a maximum. Above this temperature with higher water contents, a water cloud is thrown out first, followed by an oil cloud at a lower temperature. The

TABLE 1
Physical Properties of Aliphatic Ketones

	Mol. Weight	Boiling Point, F.	20 D_4	20 °D	Absolute Viscosity cp. 20° C.	Water Solubility at 20° C. Weight Percent Water	Water Solubility at 20° C. Weight Percent Ketone	Percent Water & B.P. °F. of Azeotrope		Flash Point °F.
C_3 Ketone										
Acetone	58.08	133.7	0.791	1.3590	0.324	complete	complete	Non-azeotrope		15
C_4 Ketone										
M.E.K.	72.06	175.0	0.805	1.3791	0.425	11.50	27.33	11.0	156°	35
C_5 Ketones										
M nP K.	86.08	215.6	0.811	1.3901	0.494	3.30	5.95	13.5	181°	
M iP K.	86.08	203.0	0.810	1.3879		2.39	6.53	13.0	181°	
D.E.K.	86.08	216.1	0.815	1.3927	0.456	1.45	5.08	14.0	176°	55
C_6 Ketones										
M nB K.	100.09	258.8	0.815	1.4007	0.626	2.12	1.75	min.	B.P.	95
M iB K[1]	100.09	242.2	0.802	1.3969	0.580	2.41	2.04	24.3	190°	75
C_7 Ketones										
M nA K.	114.11	302.0	0.815	1.4007	0.795	1.31	0.44	48	—	
M iA K[2]	114.11	291.2	0.813	1.4060						
D nP K.	114.11	291.4	0.817	1.4072	0.740	0.9	0.4	—	201°	105

[1] 4 methyl 2 pentanone. [2] 5 methyl 3 hexanone.

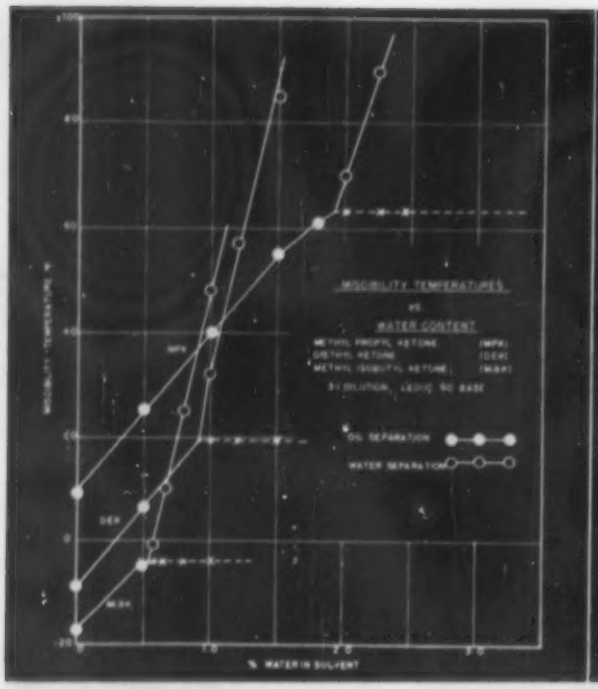


Figure 5. Miscibility temperature vs. water content.

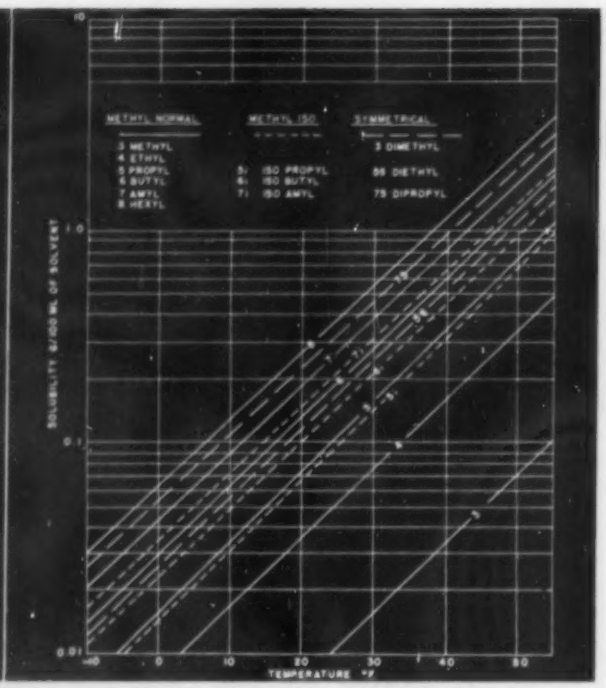
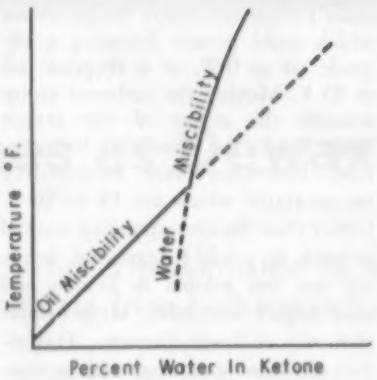


Figure 6. Solubility of 110° F. MP wax in aliphatic ketones.

effect is seen most clearly when the maximum oil miscibility temperature is low enough to cause the free water to settle out in the form of ice and the subsequent oil cloud may be easily observed (e.g. DEK). Similar results have been reported by Hall and McCarty for a Mid Continent residuum and 40/60 MEK/benzene solvent.[3]

The initial linear increase in miscibility temperature may be explained by supposing that the miscibility temperature of water with oil is about 2800-3000 F. and that the oil miscibility temperatures of mixtures of water and ketone lie on the straight line drawn between the oil miscibility temperatures of pure ketone and pure water. This would be analogous to the relationship between the miscibility temperatures of an oil with two different ketones.



Sketch A

The maximum miscibility temperature results from partial dehydration of the solution before the oil cloud point is reached. Thus, if the miscibility temperature is plotted against percent water in solvent straight lines are obained as shown in Figure 5 at low water concentrations. The plot of water miscibility temperature against percent water in ketone for an oil-ketone solution would result in a curve cutting the straight line as shown in sketch A.

In Figure 5 the horizontal maximum temperature line does not show points of oil miscibility at higher dissolved water contents, but merely indicates the temperature at which the two lines intersect. These points actually represent check determinations of the temperatures of intersection of the water and oil miscibility curves.

The slope of the oil miscibility line, and the maximum oil miscibility temperature were little affected by change in oil-ketone ratio over the range normally used in dewaxing. As would be expected, the water miscibility line was gradually displaced to lower water percentage by increasing

TABLE 2
Lubricating Oils Used in Miscibility Measurements
Phenol Treated and Dewaxed Distillates from Leduc Crude

Lube Base	Viscosity SSU at 100	Viscosity SSU at 210	Viscosity Index	Pour Solid
Leduc 60	1046	111.9	89.3	35/30
Leduc 60[1]	1827	117.0	69.1	-5/-10
Leduc 30	506	62.8	92.4	20/15
Leduc 10	184.6	43.1	89.3	10/5
Leduc 10 X	181.5	42.5	81.9	35/30
Leduc 10 X[2]	170.0	43.2	70.1	-22(solid)

[1] Dewaxed at -10 F. [2] Dewaxed at -25 F.

TABLE 3
Miscibility Temperatures of 2:1 Mixtures of Ketones and Oils

Normal Ketones	Leduc Base Oils 10X	30	60	Iso Ketones	Leduc Base Oils 10X	30	60
C_3 Acetone	130	182	219				
C_4 Methyl ethyl	27	71	98				
C_5 Methyl propyl	−37	−1	18	Methyl iso propyl	−21	+12	+33
Di ethyl	−43	−15	4				
C_6 Methyl butyl	−63	−34	−18	Methyl iso butyl	−60	−20	−10
C_7 Methyl amyl	−95	−64	−50	Methyl iso amyl	−73	−45	−28
Ethyl butyl	−102	−67	−42				
Di propyl	−106	−80	−62	Di iso propyl	−47	−15	−6
C_8 Methyl hexyl	−122	−89	−72				
Ethyl amyl				Ethyl iso amyl	−105	−84	−72

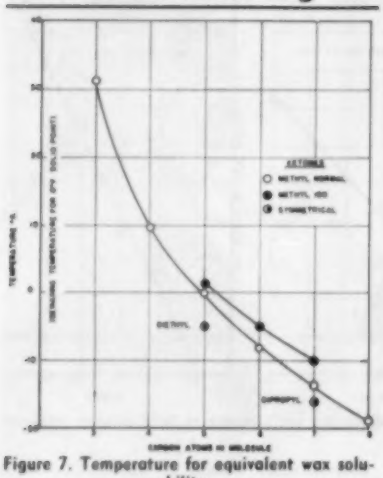


Figure 7. Temperature for equivalent wax solubility.

the oil content.

The horizontal sections of the curves shown in Figure 5 represent temperatures above which an oil phase cannot separate regardless of how much water is present. To ensure adequate oil miscibility a ketone dewaxing solvent must be dehydrated to a low water content if dewaxing is to be carried out below the maximum miscibility temperature shown in Figure 5. These data indicate that if Leduc 60 is to be dewaxed at 25 F., dehydration to about 0.3 percent water content is necessary to keep the oil in solution in MPK but that no dehydration is required if DEK or MIBK are used as solvent. DEK is borderline in this respect. However, as dehydration by azeotropic distillation is simple and effective in the case of higher ketones it is probably justified to reduce corrosion even in the cases where it is not necessary to ensure oil-ketone miscibility.

Wax Solubility—The temperature at which solvent dewaxing must be carried out to give an oil of the desired pour point is governed by the solubility of wax in the solvent.[1] Dilution also has some effect on the pour point, but this variable must be held within fairly narrow limits to obtain the best filter rates and is, therefore, of secondary importance. As refrigeration equipment and scraped surface chillers are major items of expense in a dewaxing plant, the solvent with the lowest wax solubility and the highest dewaxing temperature for a given pour point is preferred.

Although any type of wax could be used to compare solubilities in the various ketones at 110 F. melting point recrystallized paraffin wax was selected as a reference for the following reasons:

(a) The higher solubility of a low melting point wax facilitates direct solubility measurements at dewaxing temperatures of 0 to 30 F. without the extrapolations required when using a high melting wax.

(b) In solvent dewaxing, the presence or absence of low melting waxes determines the pour point of a dewaxed oil.

The solubilities of a 110 F. melting point wax in a series of ketones are shown plotted against temperature in Figure 6. Operating experience in Imperial's Sarnia plant over a period of years has shown that when dewaxing with methyl propyl ketone, the solid point of the dewaxed oil very nearly coincides with the dewaxing temperature. Assuming that MPK gives a 0 F. solid point when dewaxing a 10 grade distillate at 0 F., the other ketones shown in Figure 6 would give the same solid point at the temperature at which their wax solubilities corresponded with that of MPK at 0 F. On this basis, dewaxing temperatures for 0 F. solid points would be as follows:

Dimethyl (acetone)	+30.5F.
Methyl ethyl ketone (MEK)	+ 9.5
Methyl iso propyl	+ 1
Methyl propyl ketone (MPK)	0
Methyl isobutyl ketone (MiBK)	— 5
Di-ethyl (DEK)	— 6
Methyl butyl ketone	— 8
Methyl iso amyl	—10
Methyl amyl	—13
Dipropyl	—16
Methyl hexyl	—19

From the standpoint of wax solubility alone, acetone and MEK would obviously be first and second choices as dewaxing solvents. However both of these ketones are unsatisfactory because of poor oil solubilities (high miscibility temperatures). Of the ketones having satisfactory miscibility temperatures, the propyl ketones show the lowest wax solubilities, followed by isobutyl and diethyl ketones which require 5 and 6 F. lower dewaxing temperatures respectively than methyl normal propyl ketone.

The data shown in the above tabulation are plotted in Figure 7. It will be noted that for a given molecular weight, iso ketones would permit the highest dewaxing temperatures followed by the methyl normal and finally the symmetrical ketones (e.g. dewaxing temperatures for the C_5 ketones would be in the order: MiPK > MPK > DEK).

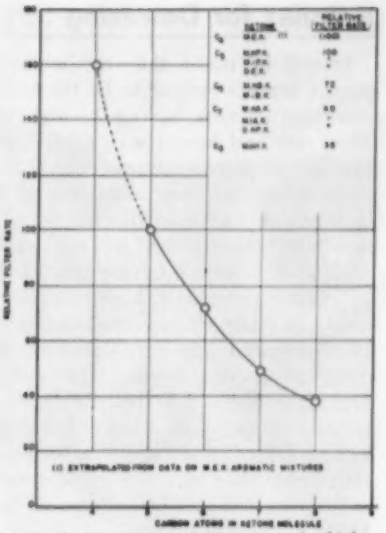


Figure 8. Comparison of filter rates for higher ketones.

In the case of MPK and DEK solvents which are 6 F. apart for equivalent was solubilities, operating data from Imperial's Sarnia dewaxing plant have closely checked predictions based on solubilities. Because solid points of dewaxed oils are difficult to reproduce with sufficient accuracy, a difference of this magnitude can only be detected by averaging a large number of determinations. Average data for the spread between dewaxing temperatures and solid points in the Sarnia dewaxing plant may be summarized as follows:

100% MPK	0.7F.
75/25 DEK/MPK	3.8F.
90/10 DEK/MPK	5.5F.

Filter Rates—Dewaxing filter rates for a series of higher ketones have been compared in the laboratory using a sample of Leduc 30 distillate diluted with 2.5 volumes of ketone. This slurry was chilled from solution temperature to 25 F. at a rate of 7 F./minute prior to filtration. Filter rates were found to be a function of molecular weight and independent of ketone structure. The rapid drop in filter rate with increasing molecular weight is shown graphically in Figure 8.

Performance of Higher Ketones—From the preceding sections the ketones showing adequate oil miscibility may be summarized with respect to to dewaxing performance as shown in Table 3a.

Ketones for Dewaxing . . .

It will be noted that the methyl propyl ketones appear to be the best dewaxing solvents, having the highest filter rate and lowest wax solubility. Methyl isopropyl ketone shows a slight advantage over normal propyl in terms of wax solubility but its oil miscibility would not be adequate (e.g. 33 F. with a 60-grade lube) for a plant processing high viscosity stocks at relatively low temperatures. Diethyl ketone appears to be next in order of merit, showing the same filter rate but a 6 F. penalty in dewaxing temperature. Methyl isobutyl ketone follows with about a 30 percent lower filter rate and a 5 F. drop in filtering temperature compared to MPK.

MEK-Aromatics and Higher Ketones as Solvents—In order to compare the higher ketones with the more common MEK-aromatic dewaxing solvents, the effect of solvent composition on dewaxing performance must first be evaluated. This has been done for MEK-toluene blends using the techniques described above. The results are plotted in Figure 9. Miscibility temperatures are shown for three reference oils with anhydrous solvents and for the limiting oil (60 grade) under conditions of water saturation. Relative filter rates are shown with MPK as a reference.

Table 3a

KETONE	Relative Filter Rate	Temperature for Equivalent Wax Solubility
C_5 methyl n-propyl (MPK)	100	0
methyl i-propyl —	100	+1
diethyl (DEK)	100	−6
C_6 methyl n-butyl —	72	−8
methyl i-butyl (MiBK)	72	−5
C_7 methyl n-amyl —	49	−13
methyl i-amyl —	49	−10
dipropyl	49	−16

TABLE 4
Performance of Dewaxing Solvents

Solvent	Temperature for Equal Wax Solubility	Relative Filter Rate	Dewaxing 60 Grade Oil to 25 F. Pour Point		
			Dewaxing Temp. °F.	Miscibility Temperatures °F.	
				Anhydrous	Saturated
Higher Ketones					
MPK	0	100	25	18	63
DEK	−6	100	19	4	19
MiBK	−5	72	20	−10	−4
MEK-Aromatics					
70/30	−4	100	21	22	68
65/35	−7	92	18	11	44
60/40	−10	82	15	0	21
55/45	−12.5	73	13	−11	5
50/50	−15	63	10	−21	<5

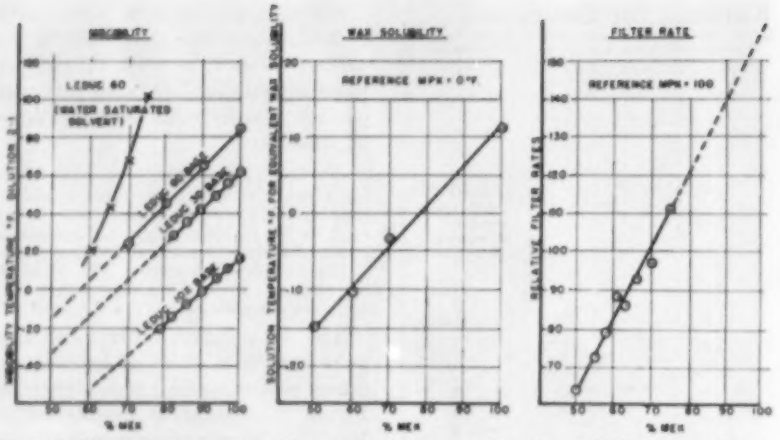


Figure 9. Effect of solvent composition on the dewaxing performance of MEK-toluene mixtures.

Wax solubilities are compared as temperatures for solubilities equivalent to that of MPK at 0 F.

Table 4 summarizes performance factors for MEK-aromatic blends and the three most attractive higher ketone solvents. In the case of the blends, filter rates and wax solubilities improve with increasing MEK contents but miscibility temperatures show the opposite effect. As an efficient dewaxing operation is not practical below the oil miscibility temperature, miscibility will be the critical factor in determining what MEK-aromatic solvent must be used.

In order to compare the blended solvents with higher ketones, a specific situation must be considered. Unless a dewaxing plant is capable of changing solvent composition to suit each stock processed, the solvent will likely be fixed by the most viscous oil processed. Dewaxing temperatures and relative filter rates have been predicted for various solvents used to dewax a 60-grade lube distillate to 25 solid point. These results as well as dry and saturated miscibility temperatures for the same oil are shown in the last three columns in Table 4. This table indicates that any of the higher ketones shown will perform in a satisfactory manner. Water content is critical only in the case of MPK. Although this solvent showns the highest dewaxing temperature and best filter rate, dehydration to a low water content is necessary to maintain the oil in solution. In the case of the blended solvents 70 percent MEK and 30 percent toluene is equivalent to MPK in filter rate but shows a 4 F. penalty in dewaxing temperature. However, this solvent would be borderline with respect to oil miscibility even with anhydrous solvent. If the MEK-aromatic dewaxing is carried out with a saturated solvent as is generally the case, Table 4 indicates that 55 percent MEK would be necessary. This solvent would show a 27 percent reduction in filter rate and a 12 F. penalty in dewaxing temperature when compared with MPK.

Conclusions—It is concluded that some of the higher ketones show better performance as dewaxing solvents than MEK-aromatic mixtures. The actual magnitude and value of this improved performance will depend on a comparison of the two types of solvent in a specific refining situation. The particular stocks to be processed will determine the composition of the MEK-aromatic blend required. When this is known, improvements in filter rates and dewaxing temperatures for a higher ketone can be readily determined.

In designing a new plant, the cost of dewaxed oil capacity obtained through the use of a higher ketone must be balanced against the cost of obtaining the same capacity by expanding the chilling and filtering sections of the plant and using an MEK-aromatic solvent. If an existing unit has sufficient solvent recovery capacity, the gains in refrigeration and filter capacity obtained by changing to a higher ketone should result directly in higher charge rates or higher yields of dewaxed oil. ##

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Figure 1. Infrared spectrometer: Light hydrocarbon analysis with speed and accuracy.

Consider Infrared for Gas Analysis

Analyzers are now becoming available for continuous analytical instrumentation on the process stream itself.

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IN THE FIELD of gas analysis, spectroscopic methods are beginning to replace standard methods involving the more conventional fractional distillation and Orsat procedures. Both mass and infrared spectrometers can provide highly accurate analyses in a fraction of the time required for the older methods. Modern instruments of these types have become so stable and reliable in operation that there is no question that present day laboratory personnel are fully capable of operating them.

The initial cost of the instruments is high—$4500 to $15,000 in the case of the infrared spectrometer and from $10,000 to $40,00 for the mass spectrometer, but the savings in laboratory manpower and the possiblities of increased plant operating efficiencies resulting from their use permit the initial investment to be paid off in a very short period.

Take for example the plant which sells 95 percent iso-butane: By fractional distillation and with extreme care it can determine iso-butane to ±2 percent. Therefore it must produce 97 percent iso-butane in order to be absolutely certain that its product meets specifications. On the other hand, through the installation of an

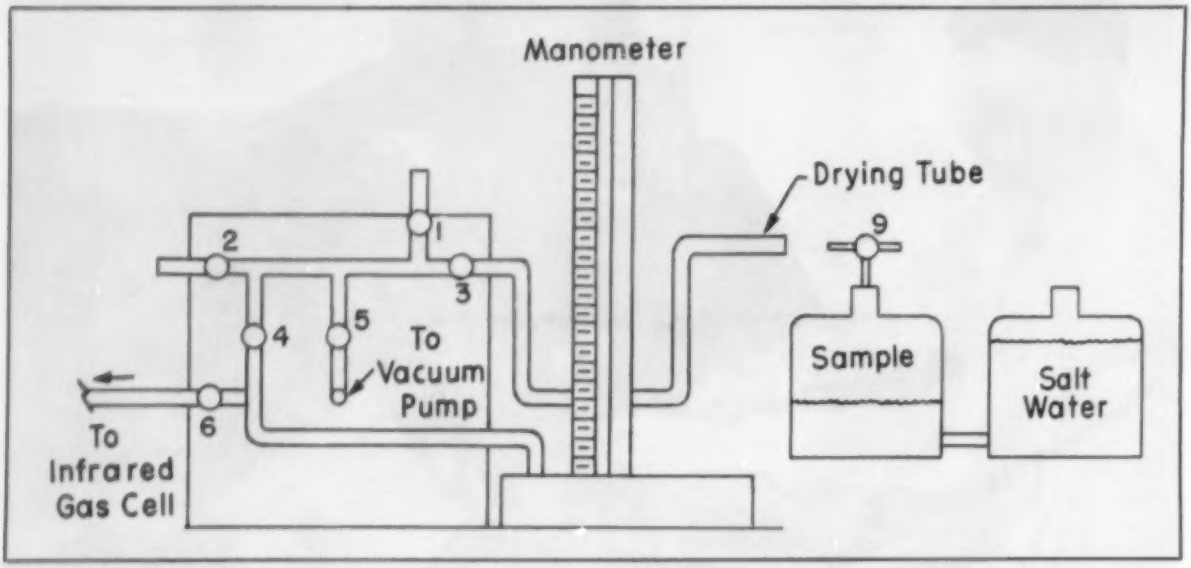


Figure 2. Needed: A simple gas handling system like this one. (Valve Nos. 1, 2, 4, 5, 6 are ¼-inch choke toggle stainless steel, Valve No. 3 is a stainless steel ⅛-inch throttling needle valve, and Valves Nos. 7, 8, 9 are glass stopcocks.)

infrared spectrometer in its control laboratory, it can determine isobutane to ±0.2 percent routinely and thus can pass with certainty, material that analyzes 95.5 percent. On this basis it doesn't take long to pay off the infrared instrument.

The next logical step would be to install continuous analytical instrumentation on the process stream itself. In this manner the plant would then have an instantaneous and continuous knowledge of what it is producing. The plant stream analyzers that make this possible are now becoming available.

Infrared vs. Mass Spectrometers—Although both the infrared and mass spectrometers are well suited for use in the gas plant laboratory there are of course advantages and disadvantages to both of them. Ideally, both instruments should be available since they are in many respects complementary. However, since economics usually dictate the selection of one or the other, the following general comments will be of interest:

For hydrocarbon analyses involving more than 10 components, the mass spectrometer is generally more feasible, since separations most often be performed for infrared analyses of mixtures of saturates and unsaturates of wide boiling range. Also the mass spectrometer can analyze for homoatomic gases such as N_2 and H_2 which have no infrared absorption.

On the other hand, many isomeric compounds (e.g. isomeric olefins) which have distinct infrared characteristics cannot be easily differentiated by the mass spectrometer.

Aside from the above facts, the two instruments are roughly equivalent in speed and accuracy on the typical four to six component analysis commonly found in the gas laboratory.

The infrared spectrometer is a much less complex instrument than the mass spectrometer. Thus, the operating and maintenance costs are considerably less.

Principles of Infrared Analysis—Infrared spectrometers and plant stream analyzers derive their usefulness from the fact that most molecules absorb infrared radiation at various specific wavelengths. No two dissimilar molecules absorb at exactly the same wavelengths. Thus, the infrared spectrum of a material serves as a means of positive identification of that material.

The infrared spectrum of a mixture is essentially the sum of the spectra of the components present. The depth of an absorption band characteristic of a particular component is proportional to the concentration of that component in the mixture. Infrared spectra may also be used as a means of accurate quantitative analysis.

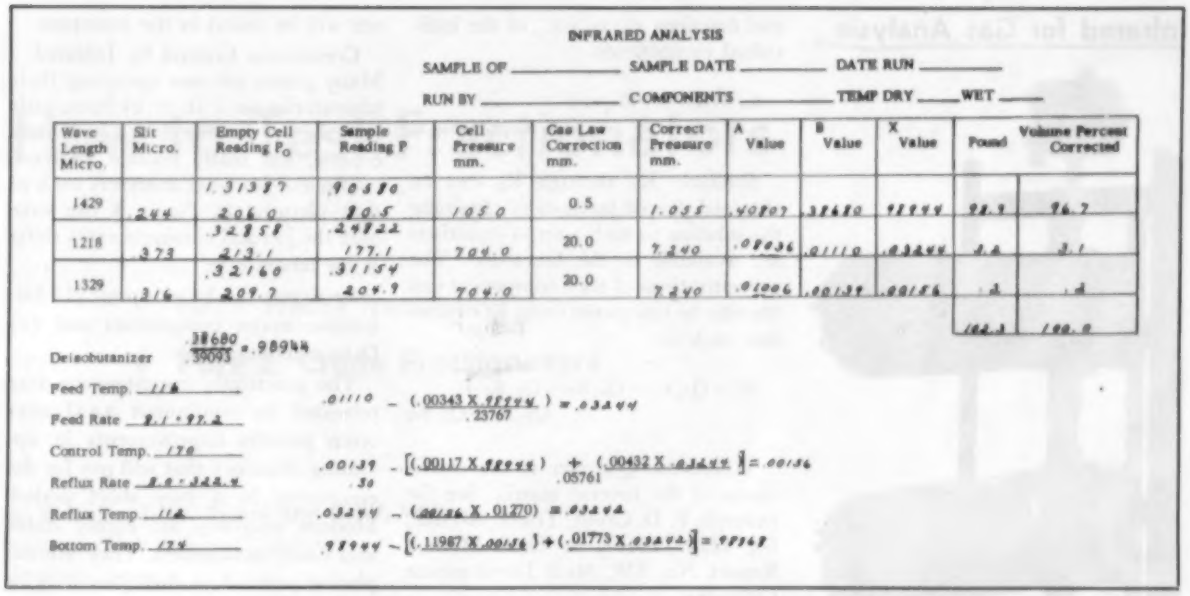
Infrared analyses may be run with ease on liquids and gases. Solids may be handled in solution, as film, or as powders mixed with powdered potassium bromide and pressed into discs.

Instrumentation for Light Hydrocarbon Gas Analysis—Most of the routine analyses that are encountered in the gas plant laboratory are multicomponent analyses where all the components are known. Thus comparatively simple infrared instrumentation will prove quite satisfactory. A typical instrument is shown in Figure 1.

For gas analysis a simple gas handling system such as that shown in Figure 2 is needed. A six by six foot laboratory floor area will accomodate the instrument and its operator.

Services required are approximately 600 watts of 110-volt, 60-cycle power and a small supply of cooling water for the spectrometer source. Humidity control to 50 percent RH is desirable —although not entirely necessary— for the protection of the crystal windows of the spectrometer and the absorption cells.

For operating an infrared spectrometer, and computing results, laboratory technicians capable of handling the apparatus normally found in a gas laboratory will prove quite satisfactory. A desk calculator, or if available, a computer capable



INFRARED ANALYSIS

SAMPLE OF _____ SAMPLE DATE _____ DATE RUN _____

RUN BY _____ COMPONENTS _____ TEMP DRY ____ WET ____

Wave Length Micro.	Slit Micro.	Empty Cell Reading P_o	Sample Reading P	Cell Pressure mm.	Gas Law Correction mm.	Correct Pressure mm.	A Value	B Value	X Value	Found	Volume Percent Corrected
1429	.244	1.31377 206.0	.90590 90.5	1050	0.5	1.055	.40907	.32680	.92944	92.9	96.7
1218	.373	.32958 213.1	.24922 177.1	704.0	20.0	7240	.00936	.01110	.03444	3.6	3.1
1329	.316	.32160 209.7	.31154 204.9	704.0	20.0	7240	.01006	.00139	.00156	.2	.2
										102.3	100.0

Deisobutanizer $\frac{.38680}{.39093} = .98944$

Feed Temp. 118

Feed Rate 2.1 + 97.2

$.01110 - \frac{(.00343 \times .92944)}{.23767} = .03444$

Control Temp. 170

Reflux Rate 2.0 + 348.4

$.00139 - \frac{[(.00117 \times .98944) + (.00432 \times .03444)]}{.30} = .00156$

Reflux Temp 118

$.03444 - (.00156 \times .01270) = .03442$

Bottom Temp. 174

$.98944 - [(.11987 \times .00156) + (.01773 \times .03442)] = .98963$

Figure 3. A sample work sheet for a routine three-component infrared analysis.

of solving simultaneous linear equations can be of great assistance in reducing computation time to a few minutes.

Specific Applications of Infrared Analysis—In virtually all light hydrocarbon gas analyses the identities of the components present are known—the requirement is usually to obtain accurate quantitative determinations of them. This simplifies the infrared procedure, usually making it unnecessary to record the infrared spectrum.

There are three phases to any quantitative infrared analysis that is to be run routinely:

Phase 1. The establishment of parameters for calculation—This involves the selection of analytical wavelengths for each component and determining the extinction coefficient of each component at each analytical wavelength. The analytical wavelengths for all the C_1 through C_5 hydrocarbon have been published (refs. 1 through 8) but extinction coefficients must be calculated for each instrument since instrument data is not completely interchangeable. An inverse matrix is usually obtained by using methods such as are outlined in the succeeding section. The procedure is somewhat time consuming but the data can be used over a long period of time. Standard mixtures are used for periodically checking the matrix.

Phase 2. Optical density measurement—Thereafter whenever the particular analysis is to be performed, the sample cell is filled and the optical density at each analytical wavelength measured. Average instrument time for a typical 5 component analysis is about five minutes.

Phase 3. Calculation—The optical density values are then inserted into the calculation matrix and the concentration of each component computed. Calculation time—2 to 10 minutes depending upon the mechanical aids available.

Typical Five-Component Analysis—Let us take an analysis involving the components propane, isobutane, normal butane, isopentane, normal pentane.

TABLE 1
Sample Table of Extinction Coefficients

Wave Length For	Microns	Micro-drive	Slit	Isobutane	Propane	Isopentane	N-Butane	N-Pentane
Isobutane	8.5	1338	0.16	0.372	0.0403	0.105	0.0059	0.0183
Propane	9.35	1610	0.24	0.0015	0.0486	0.0092	0.0053	0.0400
Isopentane	9.75	1760	0.28	0.0015	0.0066	0.159	0.0146	0.0540
N-Butane	10.4	1945	0.30	0.0033	0.0038	0.130	0.232	0.0115
N-Pentane	13.6	3400	0.84	0.0020	0.0595	0.0075	0.101	0.161

The analytical wavelengths in microns are:

Propane	9.35
Isobutane	8.5
Normal Butane	10.4
Isopentane	9.75
Normal Pentane	13.6

Extinction coefficients must be determined for each pure hydrocarbon at the five wavelengths to be used in the analysis. High purity samples of each component are required. Such can be obtained from Phillips Petro-Company or API.

The procedure is as follows:

1. Set wavelength drive to first analytical wavelength. Evacuate sample cell and adjust zero control with shutter closed until recorder reads zero. Open shutter and adjust slits until recorder reads 100 percent. Determine new slit setting at each analytical wavelength.

2. Admit the first pure gas to approximately one atmosphere pressure. Measure recorder deflection at each wavelength using slit schedule established above. Repeat procedure for each pure gas.

3. Calculate optical densities according to the formula $D = \log I_{o/I}$.

4. Calculate the extinction coefficient for all values according to the formula $K = \frac{D}{P}$ (mm Hg).

Infrared for Gas Analysis .

Figure 4. This analyzer, mounted along side the process stream, provides continuous data on stream composition making possible true analytical control.

This establishes the matrix shown in Table 1.

5. Equations

The optical density of a five-component mixture at a given wavelength A may be expressed as the sum of the optical densities of the individual components at that wavelength.

$$D = d_1 + d_2 + d_3 + d_4 + d_5$$

This expression may be developed by means of Beer's Law, etc., so that the extinction coefficient of the mixture K_A is expressed in terms of the extinction coefficients K_{A_1}, K_{A_2}, etc., mol fractions x_1, x_2, etc., of the individual components:

$$K_A = K_{A_1} x_1 + K_{A_2} x_2 + K_{A_3} x_3 + K_{A_4} x_4 + K_{A_5} x_5$$

Similarly K_B through K_E can be obtained. Rapid methods of obtaining the solution to such a set of equations are available in the literature. The concentrations of each component can thereby be calculated from an expression such as:

$$X_1 = Q_{A_1} K_A + Q_{B_1} K_B + Q_{C_1} K_C + Q_{D_1} K_D + Q_{E_1} K_E$$

Where the Q's refer to the coefficients of the inverse matrix. See for example P. D. Crout, Tranx. A-1-EE, 60, 1235 (1941), or Shell Method Report No. 339, Shell Development Company.

An analysis of a synthetic blend is shown in table II. Table III compares the analysis to the actual composition of the blend.

For the sake of brevity, detailed discussions of the selection of the proper cell pressure, as well as temperature and pressure corrections have been omitted. However, complete discussions of all phases of accurate gas analysis by infrared methods will be found in the literature.

TABLE 3

Analysis Versus Actual Composition

Component	Found	Corrected	Synthetic Percent	Deviation
Isobutane	66.3	65.6	66.0	−0.4
Propane	5.5	5.4	4.5	+0.9
Isopentane	6.3	6.2	6.1	+0.1
N-Butane	21.7	21.4	21.9	−0.5
N-Pentane	1.4	1.4	1.5	−0.1
	101.2	100.0	100.0	....

Continuous Control by Infrared—Many plants are now operating their laboratories on a 16 or 24 hour basis in order to provide data for process control. On many routine analyses, continuous infrared analyzers such as that pictured in Figure 4 can take over the job and eliminate extra shifts in the laboratory.

Analyzers can be set up to: (1) Determine major components and (2) Determine impurities.

The practically instantaneous data provided by continuous analyzers often permits improvements in operating efficiency that will pay for the equipment in a very short period. Modern analyzers are highly stable and easily maintained. They are explosion proofed so that they may be installed anywhere in the plant. Their recorders may be mounted on the plant control panels. They provide automatically and continuously the analytical data without which the process cannot be efficiently controlled. Thus, they make possible true "analytical control."

Original presentation of this paper was at the Symposium on Methods for Testing Liquified Petroleum Gases, September 27, 1954. ##

ACKNOWLEDGMENTS

The author is deeply grateful to the many laboratories that have provided data and information for this paper. Specific mention should be made of W. Priestly, Esso Standard Oil, for supplying the data for the typical five component analysis; R. C. Wilkerson of Celanese for the series of hydrocarbon analyses; Fletcher Hickerson and Sam Hastings of Humble Oil, and Chester Keagy of Katy Gas Cycling Plant for data on routine procedures.

A work sheet used in a gas cycling plant is given in Figure 3. It covers a routine, three component analysis (propane, normal butane, iso-butane). At this plant hourly analyses are run 16 hours a day, as well as 24 hour cumulative samples.

TABLE 2

Infrared Analysis, C_3-C_4-C_5 Saturates

% Isobutane	= + 270.5 (0.257)	− 323.6 (0.0059)	− 139.0 (0.0153)	− 33.7 (0.0612)	+ 98.7 (0.0293) = 66.3
% Propane	= − 8.9 (0.257)	+ 2852.0 (0.0059)	− 296.1 (0.0153)	+ 225.5 (0.0612)	− 624.3 (0.0293) = 5.5
% Isopentane	= − 2.5 (0.257)	+ 230.1 (0.0059)	+ 574.0 (0.0153)	+ 69.4 (0.0612)	− 254.3 (0.0293) = 6.3
% N-Butane	= − 2.4 (0.257)	− 122.3 (0.0059)	+ 329.2 (0.0153)	+ 405.8 (0.0612)	+ 112.1 (0.0293) = 21.7
% N-Pentane	= + 1.6 (0.257)	− 984.0 (0.0059)	+ 290.9 (0.0153)	− 340.7 (0.0612)	+ 792.2 (0.0293) = 1.4

TABLE 4

Typical Gas Analysis—Paraffins C_1 to C_5

	CH_4	C_2H_6	C_3H_8	iC_4H_{10}	nC_4H_{10}	$neoC_5H_{12}$	iC_5H_{12}	nC_5H_{12}
	7.86 500 mm Hg.	12.28 300 mm Hg.	9.34 600 mm Hg.	8.46 100 mm Hg.	10.30 135 mm Hg.	7.94 40 mm Hg.	9.78 200 mm Hg.	10.94 180 mm Hg.
Methane	.782	.010	.005	.008	.006	.050	.006	.007
Ethane	.025	.750	.006	.005	.005	.002	.006	.024
Propane	.128	.036	.624	.112	.015	.012	.032	.239
Isobutane	.212	.115	.028	.771	.014	.017	.012	.353
n-Butane	.387	.076	.081	.032	.738	.023	.065	.036
neo-Pentane	.871	.013	.041	.051	.024	.801	.012	.183
iso-Pentane	.909	.118	.137	.277	.463	.045	.769	.305
n-Pentane	.899	.050	.431	.056	.043	.073	.258	.740

Remarks: Methane broadening correction necessary.

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How to Test Fractionators

Part 1. Precise Fractionators

Part 2. Crude Fractionators

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SUCH REFINERY operations as the atmospheric and vacuum distillation of crude oil; rerunning of treated naphtha, kerosine, and heating oil; the fractionation of the products of cracking and cycle stock in thermal cracking operations; and the fractionation of products from catalytic cracking operations require the separation of wide boiling range products. Although the general approach to testing and evaluating towers in these services is the same as for precise fractionators, the complex composition of the feeds and products involved complicates the calculations required to define the capacity of the tower and the degree of separation effected therein. Also the operating conditions and requirements of separation require some deviation in design from the general type tower found in precise fractionation service.

As a basis for the discussion, atmospheric crude distillation towers and catalytic cracking unit fractionators will be used as examples. The problems in testing and evaluating these two types of towers are typical of those that might be encountered in any service where the object is to separate wide boiling range products.

General Tower Design—The crude distillation towers and catalytic cracking unit fractionators differ somewhat from the towers normally used to separate light hydrocarbons. Figure 1 shows a schematic diagram of a typical catalytic cracking unit fractionator. One difference is the use of

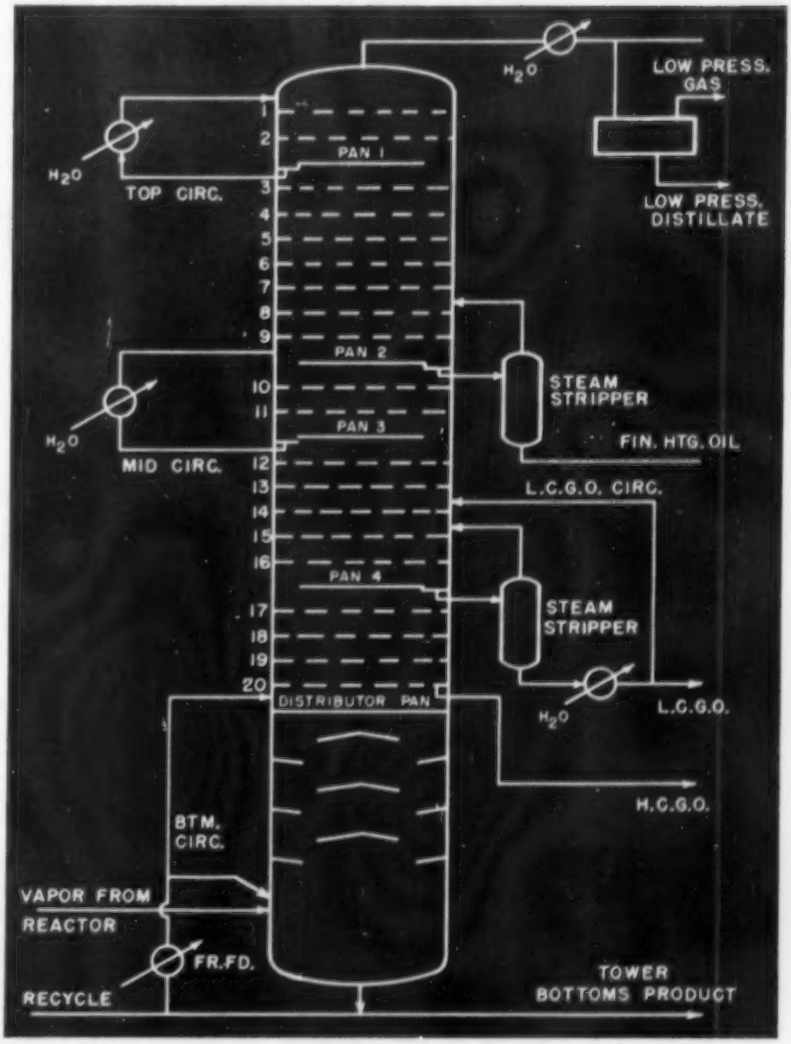

Figure 1. Primary fractionator for catalytic cracking unit.

pumparound circuits on the unit to remove heat and induce reflux rather than obtaining all the reflux from condensed overhead vapor. By the location of the pumparound circuits at several levels on the tower it is possible to more nearly balance the vapor and liquid loading throughout the tower. This is not done, however, without some loss in fractionation. As the heat removal is shifted down the tower to reduce the load on the top sections, the degree of separation in the top sections is reduced. Also, there is a loss in theoretical or equilibrium plates by the inclusion of several plates in pumparound circuits. The number of plates required in a pumparound circuit to remove a specified amount of heat may be estimated from empirical correlations but it is beyond the scope of this article to give the details of the procedure. Several sidestreams are normally withdrawn from these towers. This adds to the complexity of the calculations involving the degree of separation and yields. The towers consist essentially of a rectifying section only with steam stripping of the bottoms and the sidestream products. All of the heat available for separation is introduced in the feed. In the case of crude distillation units a furnace is necessary to preheat the feed but in the case of catalytic cracking unit fractionators the vapor from the reaction section contains considerable superheat and, therefore, a "desuperheating" section is necessary. This normally consists of a baffled section in the bottom of the tower where the heat is removed in a pumparound stream.

Capacity Tests—In capacity tests on crude distillation towers and catalytic cracking unit fractionators the primary objectives are the same as those discussed for the case of precise fractionators. Basically, the problem is to define the combination of vapor and liquid rates at which spilling starts. Since the effect of these rates on the spilling point are not independent of each other, it is desirable to experimentally determine the spilling point for several combinations. Sometimes this is not possible due to limitations in other parts of the equipment; however, a method has been published by Atkins[1] which enables one to calculate the relationship between vapor and liquid rates.

The temperature drop across these towers is large giving wide variation in vapor and liquid rates because of sensible heat effects. As mentioned previously, the use of pumparound circuits tends to balance this effect but there is still considerable variation. Consequently it is desirable to determine the capacity of each section of the tower. Frequently, however, the capacity of the pumparound sections will not permit the intermediate sections to be loaded to capacity. The load in the bottom sections of the tower may be increased independently by increasing feed rate or by increasing the steam rate to the tower bottom or to the catalyst stripper in the case of catalytic cracking unit towers. The load in the upper sections of the tower may be increased independently by reducing the heat removal in the pumparound circuits below or by addition of steam to the sidestream strippers.

For example, the procedure for testing the capacity of the top pumparound section of a tower would be to reduce the rate of the next lower or second pumparound stream gradually, increasing the top pumparound rate to maintain total heat removal constant. If reducing this stream rate to zero does not provide enough additional load to spill the top section the next step would be to gradually reduce the next lower or third pumparound stream. This may result in the second pumparound section spilling before the top pumparound section. If so, the third pumparound rate would be raised such that this is just prevented and the additional load required to spill the top pumparound section provided by introducing more steam to the top sidestream stripper. By changing the relative amount of steam added either with the feed or in the sidestream strippers it may be possible to obtain spilling data at two or more ratios of liquid to vapor rate. As was stated previously, this is desirable in evaluating the relative effect of vapor and liquid rates on tray performance.

In conducting the capacity tests it is necessary to define accurately the incipient spilling point. One method of doing this is by the use of differential pressure instruments. As the loading on the tower is gradually increased the pressure drop will also gradually increase up to the spilling point. At this point there is a sharp rise in differential pressure. This can be seen in Figure 2. As stated previously in the discussion on precise fractionators it is important not only to determine the rates at which spilling starts but also the point in the tower where it begins. Therefore, it is desirable to have differential pressure instruments over small sections of the tower. This also permits the pressure drops over a small section to be checked by calcuation.

Another method of determining the spilling point is by the use of bleeder valves. Although they are not as clear cut in this service as in light hydrocarbon towers, they have been used successfully in the top sections of catalytic cracking unit fractionators. The bleeder can be located on the external manheads and should be approximately at the center of the tray spacing. If the bleeder is opened to the atmosphere before spilling starts a cloud of vapor is encountered. After spilling starts the stream is predominantely liquid. One limitation to the use of bleeders in detecting spilling is that either the plate at which spilling will start must be known or bleeders must be installed on practically all trays. Another limitation is that there is no indication of the approach to the spilling point as there is with differential pressure recorders.

The rates on the tower should be raised in small increments and the unit allowed to line out between increases. All data should be obtained during these lined out periods. Here, as with precise fractionators, the amount of time needed for the unit to line out depends on the size of the incremental increases in internal loadings. The optimum test procedure, therefore, is to determine the approximate spilling point by rapid increases. Then it will be possible to adjust the loadings not far below this point and make another, more careful approach to the spilling point. The data necessary are those that are required to give heat and material balances and to define the composition and physical characteristics of the internal vapor and liquid streams. All feed and product rates and steam rates are needed and sufficient temperatures should be obtained to permit heat balances around each section of the tower. The pressure at some point on the tower is needed and differential pressures across all sections of the tower. Since the value of these

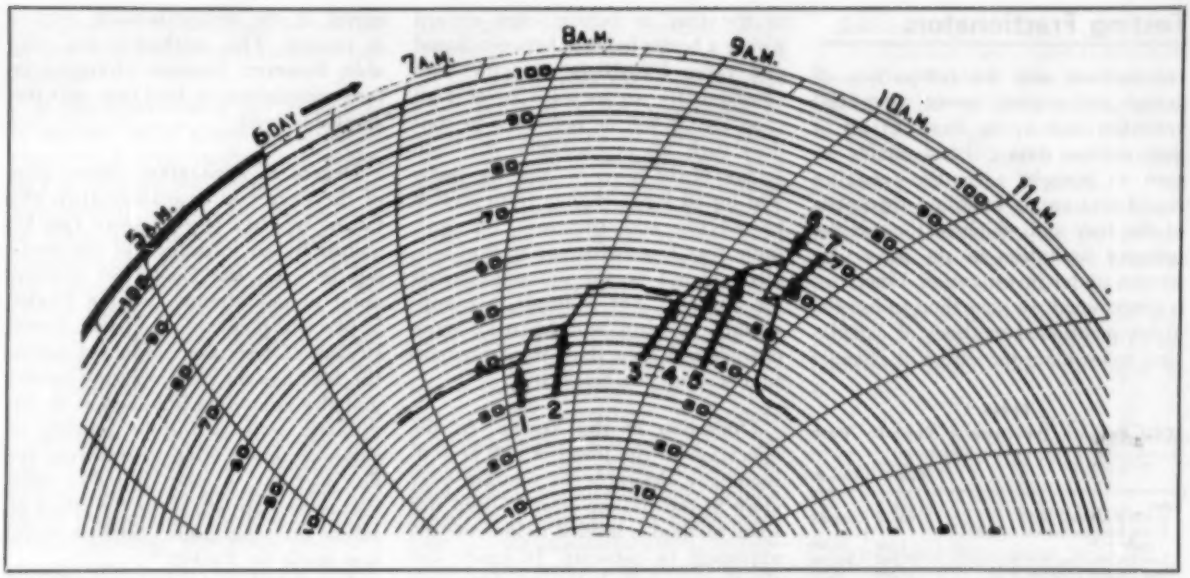

Figure 2. Differential pressure chart for top nine trays of catalytic cracking unit fractionator.

Points: (1) Reduced mid curculation rate 3500 b/d to increase load in top section. (2) Reduced mid curculation rate 3500 barrels per day. (3). Increased feed to unit. (4). No changes made. Spilling indicated in top section by pressure drop in this section continuing to increase. (5). Spilling confirmed by presence of liquid in material from bleeder valve located above top tray. (6). Increased mid circulation to reduce the load in top section. (7). Increased mid curculation and light cycle gas oil circulation.

tests depends upon the accuracy of the data taken, all meters, temperature indicators, pressure gages and pressure recorders should be checked before the test is started. Just before the spilling point is reach samples of all product streams should be taken.

ASTM and true boiling point distillations and gravities for all liquid products and component analyses of light hydrocarbon products should be obtained. From these data such information as molecular weights, characterization factors, heat contents, thermal expansions, and vapor pressures can be estimated from published correlations such as those by Maxwell.[17] If samples of the product streams are not obtained before the spilling point is reached, the internal rates should be reduced just below the spilling point and the tower allowed to line out there and then the samples taken.

In some cases, depending upon the type limitation that exists, the use of gage columns provides valuable information as to possible tray modifications. These gage columns may be located at several points across the tray and in the downcomers to show the height of clear liquid at these points. By locating taps at several levels in the downcomer it is possible to determine the density of material in the downcomer relative to clear liquid.

Analysis of Capacity Test Data—In evaluating the towers from the test data it is necessary first to determine the internal vapor and liquid loadings at incipient spilling by a heat balance for the tray at which the spilling initiated. In order to do this the physical and thermal characteristics of the vapor and liquid on the tray in question must be known. These may be established by stepwise equilibrium calculations by a method that will be discussed later; however, this is a long and tedious procedure and, in general, is not waranteed. The physical characteristics may be determined by interpolation between adjacent product streams and from these physical characteristics the heat content may be estimated. Although there may be some doubt as to the accuracy of the estimated heat content above a given datum plane for boiling range fractions, the relative heat contents, which are the things of interest, should be fairly good.

Things of interest, such as downcomer velocities, tower superficial vapor velocities, height of clear liquid over the outlet weir, pressure drop under the downcomer, and dry and wet tray pressure drop can be calculated using the internal loadings. The height of clear liquid over the outlet weir can be calculated by Francis' weir formula. The pressure drop under the downcomer can be calculated by conventional fluid flow principles. Methods for calculating dry tray pressure drops have been presented by several investigators including Dauphine,[4] Edmister,[6] and Brown.[2] The calculated pressure drop by these methods should be compared with the observed pressure drops. Some of the methods compare better than others for a particular tray layout and cap design and the one that corresponds closest to the observed pressure drop should be used in evaluating changes in tray loadings. Here again the relative values calculated by the various methods should be good even though the absolute value is in error. Good, Hutchinson, and Rousseau[11] give a method for predicting the hydraulic gradient across the tray. Kemp and Pyle[13] also give data on hydraulic gradients. Equations similar to that recommended by Souders and Brown[20] may be used to determine the critical vapor velocity with respect to entrainment. The values calculated by this equation using constants presented in the literature give conservative answers for maximum vapor rate but directionally they give a good idea of the approach to an entrainment limitation.

The capacity factor method of Atkins[1] shows the effect of the interrelationship between vapor and liquid rates on tower spilling. By an inspection of the results of the tray hydraulic calculations, capacity factor

calculations, and the comparison of actual and critical tower superficial velocities and by an inspection of gage column data if it is available we gain an insight as to the relative liquid and vapor handling capacities of the tray and which of these is the primary limitation in the particular section under investigation. Once this is determined we may then utilize the above-mentioned methods of calculation to estimate the effect of changes to the tray or bubble caps toward giving a better balance between liquid and vapor handling capacities and consequently an increase in over-all capacity. It will be necessary to conduct such an investigation for each section of the tower because the vapor and liquid loads change from section to section and, therefore, the optimum tray layout for one section usually will not be the optimum layout for another. For example, a pump-around section will require more downcomer area than the fractionation section just below it.

TABLE 1

FCCU Primary Fractionator Capacity Data

	Case A	Case B
Rates		
FCCU Fresh Feed, B/D	40,150	45,600
Tower Bottoms Recycle to Reactor, B/D	4,308	13,950
Low Pressure Gas, SCF/Hr.	978,000	945,000
Low Pressure Distillate, B/D	17,560	18,850
Finished Heating Oil, B/D	12,150	12,200
Light Cycle Gas Oil, B/D	2,000	3,000
Heavy Cycle Gas Oil, B/D	0	3,150
Tower Bottoms Product, B/D	1,620	2,080
Steam to Fractionator Bottom, Pounds/Hour		
Steam to Finished Heating Oil Stripper, Pounds/Hour	5,760	1,200
Steam in Vapor from Reactor, Pounds/Hour	17,370	21,190
Top Circulation, B/D	59,100	53,700
Mid Circulation, B/D	8,400	3,500
Light Cycle Gas Oil Circulation, B/D	0	1,600
Bottom Circulation, B/D	73,700	90,300
Coke, Pounds/Hour	26,300	36,700
Temperatures		
Fractionator Overhead Vapor	290	308
Top Circulation Draw-off	345	365
Top Circulation Return	185	182
Tray 3 Vapor	398	390
Finished Heating Oil Draw-off	510	520
Tray 10 Vapor		
Mid Circulation Draw-off	548	538
Mid Circulation Return	128	90
Tray 12 Vapor	580	575
Light Cycle Gas Oil Draw-off	592	600
Light Cycle Gas Oil Circulation Return		125
Tray 17	588	600
Tray 20	598	605
Tower Bottom	687	695
Bottom Circulation Return	530	503
Vapor From Reactor	910	900
Pressures and Pressure Drops		
Tower Bottom Pressure, psig.	20.0	19.6
Press. Drop (Tower Btm.—Tray 20), psi.	0.44	0.76
Press. Drop (Trays 12-20), psi.	1.30	1.57
Press. Drop (Trays 10-11), psi.	0.47	0.24
Press. Drop (Trays 4-9), psi		2.03
Press. Drop (Trays 1-3), psi.	0.67	
Gravities		
Low Pressure Gas (Air at 60° F. = 1.0)	1.34	1.36
Low Pressure Distillate, °API	53.7	53.0
Finished Heating Oil, °API	25.7	28.0
Light Cycle Gas Oil, °API	24.8	26.0
Heavy Cycle Gas Oil, °API	24.2	25.0
Fractionator Bottoms, °API	16.6	17.0
Fresh Feed, °API	26.5	25.5

TABLE 2

Typical ASTM Distillations of Liquid Streams

Percent Off	Low Pressure Distillate	Fin. Htg. Oil	Light Cycle Gas Oil	Heavy Cycle Gas Oil	Fract. Twr. Btms.
IBP	96	434	300	308	385
5	142	500	588	595	655
10	168	510	611	623	676
20	202	524	630	650	697
30	232	538	642	666	
40	260	548	650	678	
50	290	560	658	688	
60	320	572	664	698	
70	342	586	670	700	
80	384	600	677		
90	418	620	686		
95		634	696		
FBP	480	648	715		

Operation of the Tower—In the operation of the tower it will be economically desirable to operate very close to the spilling point. To do this some method is needed to indicate the approach to capacity. In crude distillation or catalytic cracking unit towers the differential pressure instrument affords one of the best measures of this approach to spilling. Since the feed composition and heat input to these towers are subject to change, the loadings on the tower will also change. Although the pressure drop at which spilling starts may vary slightly for a given section, the critical pressure drop can be determined and operation conducted at a slightly lower value to allow for fluctuation in loading. Another method that has been used in catalytic cracking fractionators where the limitation is in the bottom tray section is control by bottom tray temperature. For a given operation this temperature is indicative of the vapor load leaving the "desuperheating" section. Here the maximum allowable temperature is determined and then maintained below this level by changing the heat removal in the desuperheating section as needed. This method is less reliable, however, because changes in feed composition or feed rate shift the allowable level.

Degree of Separation—Some idea of the degree of fractionation obtained in this type tower can be gained by an inspection of the overlap between the Engler 95 percent point of one stream and the Engler 5 percent point of the next lower stream. If tests are conducted where the loadings on the tower are varied and the same data obtained as in the capacity tests, it will be possible to examine this overlap at different reflux ratios. A plot of reflux ratio versus overlap will show the effect of reflux on separation. Such a study was made by Packie.[16]

In addition to this empirical method of estimating the degree of separation, it is possible to make detailed plate-to-plate calculations in this type tower. A method for doing this was presented by Lewis and Wilde.[15] The use of plate-to-plate calculations in this case, however, is more complex than in the case of towers separating light hydrocarbons and the results are less accurate. To accomplish these calculations the feed is broken down into small boiling range fractions, say 50° ranges, from a true boiling point distillation. These fractions are then treated as individual components. Vapor pressure data for the boiling range fractions can be obtained from such literature as that presented by Maxwell.[17] Raoult's law is assumed valid and the plate-to-plate calculations performed in the usual manner starting at either the top or bottom of the column. The

TABLE A

Stream	B/D	°API	Lb./Gal.	Lb./Hr.	Temp. In	Temp. Out	Btu./Lb. In	Btu./Lb. Out	Btu./Hr.
Low Press. Gas	978,000	SCF/Hr.	MW = 38.9	100,400	910	290	832	410	42,369,000
Low Press. Dist.	17,560	53.7	6.361	195,500	910	290	754	363	76,441,000
Fin. Htg. Oil	12,150	25.7	7.495	150,400	910	510	714	342	59,297,000
Lt. Cycle Gas Oil	2,000	24.8	7.539	26,400	910	592	712	397	8,316,000
Twr. Btms. Product	1,620	16.6	7.956	22,000	910	687	697	452	5,537,000
Coke				26,300					
Total Products				530,600					
Fresh Feed	40,150	26.5	7.458	524,000					
Error				6,600					
Error, % on Feed				1.26					
Steam from Reactor				17,370	910	290	1487	1184	5,263,000
Steam to Tower				5,760	364	290	1195	1184	68,000
Recycle	4,308	16.6	7.956	60,000	910	687	697	452	14,700,000
Top Circ.	59,100	48	6.563	678,800	185	345	166	258	(62,450,000)
Mid Circ.	8,400	25.5	7.505	110,300	128	548	128	367	(26,362,000)
Btm. Circ.	73,700	16.6	7.956	1,020,200	530	687	345	452	(109,803,000)
Error									13,371,000
Total heat input									211,986,000
Error, % on heat input									6.31

pumparound sections may be treated as one equilibrium step in these calculations.

If the separation is not known, as is the case when a new operation or new feed is being studied, it is necessary to estimate the yields of the various product streams for the purpose of establishing the operating line equations and then proceed to make the plate-to-plate calculations to establish the product stream compositions. The assumed yields are then checked by a material balance and the procedure repeated until a balance is obtained. In these calculations plate efficiency should always be considered. Because of the wide temperature change across the tower and the use of pumparound circuits and sidestream drawoffs, the reflux ratio will change considerably across the tower.

The reflux ratio between each plate should be established by heat balances. This also is a trial-and-error calculation and is time consuming. When the drawoff composition is established the boiling range fractions can be recombined to construct a true boiling point distillation curve for each product. The time required in establishing the yields and making the heat balances by trial-and-error impose one of the limitations to the use of this technique. It is useful in the design of new units or in evaluating the operation on a considerably different type feed but for small changes in operation there is often not time or justification for such detailed calculations.

One solution to the time requirement problem is the application of machine computors to plate-to-plate calculations for this type tower. This has been accomplished in the case of a rerun tower in which the boiling range of the feed is not as wide as in the case of crude distillation towers or catalytic cracking unit fractionators. In this application relative volatilities were not assumed constant but a method for interpolation for the correct relative volatility was incorporated in the procedure. By adding sufficient number storage space to the computor it would be possible to apply this procedure to wider boiling range feeds and also to incorporate heat balance calculations into the procedure. This would add greatly to the possible utilization of plate-to-plate calculations involving the separation of complex mixtures.

Example of Tower Analysis—*Problem:* The primary fractionator at a Fluid catalyst cracking unit is operating near maximum capacity and occasionally is the limiting factor in the unit operations. Figure 1 is a schematic diagram of the tower. From differential pressure instruments it is evident that the top pumparound section is the critical point. It is desirable to increase the capacity to give more operating flexibility and to increase reflux ratios between the overhead and the heating oil drawoff tray.

TABLE B

Stream	Lb./Hr.	°API	Temp. In	Temp. Out	Btu./Lb. In	Btu./Lb. Out	Btu./Hr.
Low Press. Gas	100,400	MW = 38.9	398	290	409	410	5,924,000
Low Press. Dist.	195,500	53.7	398	290	417	363	10,557,000
Total Steam	23,130		398	290	1237	1184	1,226,000
Top Circ.	678,800	48	185	345	166	258	(62,450,000)
Overflow to Tray 3	x	48	398	345	413	258	155(x)
							0

155(x)—44,743,000=0
x=288,700 lb./hr.
Total overflow from Tray 2=288,700 + 678,800
=967,500 lb./hr.

LIQUID RATE—θ_2

Lb./Hr.	°API	Lb./Gal.	Temp. Corr.	Gpm at Flow Temp.	Cfs at Flow Temp.
967,500	48	6.563	0.86	2860	6.37

VAPOR RATE—V_2

	Lb./Hr.	Mol. Wt.	Mol./Hr.	Temp.	Press.	Cu. Ft./Sec.
Low Press. Gas	100,400	38.9	2581			
Low Press. Dist.	195,500	112	1746			
Steam	23,130	18	1285			
Overflow to Tray 3	288,700	120	2406			
	607,730	75.8	8018	398	30.9	664

Solution:

(1) Capacity tests were conducted. Case A in Table 1 gives the data obtained at the incipient spilling point in the top pumparound section.

(2) Over-all material and heat balances are shown in Table A.

(3) Heat balances around the various trays revealed that the second tray from the top had the heaviest load.

The heat balance around the top two trays is given in Table B to establish the liquid from and vapor to this tray.

(4) Downcomer Velocity

Downcomer Area = 11.42 square feet

$$V_D = \frac{6.37}{11.42} = 0.56 \text{ fps}$$

(5) Tower Superficial Velocity

Free Area = 202.5 square feet

$$\text{Superficial Velocity} = \frac{664}{202.5} = 3.28 \text{ fps}$$

Design Superficial Velocity

$$V_s = K\left(\frac{D_L - D_v}{D_v}\right)^{0.5}$$

From Perry's "Chemical Engineers' Handbook"[19]

$$K = 0.183$$

$$V_s = 0.183\left(\frac{42.3 - 0.254}{0.254}\right)^{0.5} = 2.35 \text{ fps}$$

Tower Superficial Velocity, Percent of Design = 140 Percent

(6) Tray Pressure Drop

Equations for the calculation of pressure drop through various parts of bubble caps are those which are used by The Texas Company[5] and by Standard Oil Development Company.[12] These equations were originally developed by T. C. Dauphine[4] and are as follows:

(A) Pressure drop through riser

$$\Delta P_t = \frac{0.00158}{S_L}\left(\frac{A_t}{A_s}\right)^{0.5} d_t\left[(D_v)^{0.5}\frac{V_T}{A_t}\right]^{1.89}$$

(B) Pressure drop through reversal and annular spaces

$$\Delta P_r = \frac{0.0109}{S_L}\left[(D_v)^{0.5}\frac{V_T}{A_t}\frac{2A_t^2}{A_M A_2}\right]^{1.81}$$

(C) Pressure drop through wet slots

$$\Delta P_s = 0.025\frac{D_v}{S_L}\left(\frac{V_T}{A_{sL} + A_{sh}}\right)^2$$

A_t = Total riser area, sq.ft. = 26.2
A_s = Total reversal area, sq.ft. = 16.4
S_L = Specific gravity of liquid = 0.68
d_t = Riser diameter, inches = 4.0

Testing Fractionators . . .

D_V = Vapor density, lb./cu.ft. = 0.254
V_T = Total vapor, cu.ft./sec. = 664
A_m = Minimum of cap annular or reversal areas, sq.ft. = 16.4
A_t = Total cap inside area, sq.ft. = 58.9
A_{sL} = Open slot area, sq.ft. = *
A_{sk} = Open skirt area below cap, sq.ft. = *

* Trial and error

$$\Delta P_1 = \frac{0.00158\,(4)}{0.68}\left(\frac{26.2}{16.4}\right)^{0.5}\left[(0.254)^{0.5}\left(\frac{664}{26.2}\right)\right]^{2.18}$$

= 2.47 (Inches of liquid at tray conditions)

$$\Delta P_2 = \frac{0.0109}{0.68}\left[(0.254)^{0.5}\left(\frac{664}{26.2}\right)\frac{2\,(26.2)^2}{(16.4)\,(58.9)}\right]^{1.11}$$

= 2.28 (Inches of liquid at tray conditions)

$$\Delta P_3 = 0.025\left(\frac{0.254}{0.68}\right)\left[\frac{664}{A_{sL}+A_{sk}}\right]^2$$

Assumed Height of Open Section	$A_{sL}+A_{sk}$	P_3
1.375	33.2	3.72
1.75 (max.)	47.9	1.79

Total cap pressure drop = $\Delta P_1 + \Delta P_2 + \Delta P_3$
= 2.47 + 2.28 + 1.79
= 6.54 inches of liquid

Clear liquid head over outlet weir

From Francis' weir formula given in many texts.

$$h_{ow} = \left[\frac{Q}{2.98\,L_W}\right]^{0.667}$$

Q = hot liquid flow, gpm = 2,860
L_w = length of weir, inches = 368

$$h_{ow} = \left[\frac{2{,}860}{2.98 \times 368}\right]^{0.667}$$

= 1.90 (Inches of hot liquid)

The effective hydrostatic head is calculated from a relationship shown in Figure 3 which was developed by one of the authors.

$\Delta P_3 = K\,[h_w + h_{ow}] = h_s + 1/2\,h_s$
h_w = height of outlet weir, in. = 1.25
h_{ow} = liquid head over weir, in. = 1.90
h_s = height of slots above tray, in. = 1.75
h_s = assumed height in determining A_{sL} and A_{sk} in calculation of P_3 = 1.75
K = obtained from Figure 3 = 0.69

$$\Delta P_3 = 0.69\,[1.25+1.90] - 1.75 + \frac{1.75}{2}$$

= 1.30

Total tray pressure drop = total cap drop + effective hydrostatic head
= 6.54 + 1.30
= 7.84 (Inches hot liquid)

Observed pressure drop (Average per tray) on top three trays = 9.1 inches hot liquid
Calculated tray pressure drop, percent of observed = 86.2 percent

(7) Height of liquid in downcomer

H = tray $\Delta P + h_w + h_{ow} + h_{hz} + \Delta P_3$
h_{hz} = Hydraulic gradient
ΔP_3 = Pressure drop due to liquid flow reversal under downcomer.

The hydraulic gradient is estimated from the data reported by Kemp and Pyle.[12]

h_{hz} = 4.0" hot liquid

$$\Delta P_3 = 0.057\left(\frac{Q}{A_c}\right)^2$$

Q = Hot liquid flow, gpm = 2,860
A_c = Minimum area under downcomer, sq.in. = 611

$$\Delta P_3 = 0.057\left(\frac{2860}{611}\right)^2$$

= 1.25 inches hot liquid

H = 7.84 + 1.25 + 1.90 + 4.0 + 1.25
= 16.24 inches

Tray spacing plus outlet = 31.25

Height of clear liquid in downcomer, percent of tray spacing plus outlet weir = $\frac{16.24}{31.25} = 52\%$

(8) Capacity factor rating

This method was proposed by G. T. Atkins[1] to show the interrelation of vapor and liquid loads.

Required Area:

$$\text{For caps} = (W/F)\left[\frac{62.4}{10.73\,D_V\,(D_L - D_V)}\right]^{0.5} = a$$

For downcomer and seal = $f_h\,(Q_t + Q_e) = b = c$

W = Vapor rate, lb./hr. = 607,730
F = Constant for given plate spacing = 2800
D_V = Vapor density, lb./cu.ft. = 0.254
D_L = Liquid density, lb./cu.ft. = 42.3
f_h = Constant for given plate spacing and stream gravities = 0.0064
Q_t = Hot liquid flow, gpm = 2860
Q_e = Liquid entrained, gpm = function of required and installed cap areas
b = Downcomer area
c = Seal area

$$\text{Capacity factor} = \left[\left(\frac{a}{1.2A}\right)^2 + \left(\frac{b}{1.8B}\right)^2\right]^{0.5} 100$$

A = Installed cap area
B = Installed downcomer area

Required Area			
For caps	= a		= 160
For downcomer	= b	= 0.0064 (2860 + 167)	= 19.4
For seal	= c		= 19.4
			198.8
Installed Area			
For caps	= A		= 158.6
For downcomer	= B		= 10.85
For seal	= C		= 10.85
		Ineffective Area	= 33.70
			214.00
Comparison			
% of vapor capacity	= (a/A) 100		= 101
% of liquid capacity	= (b/B) 100		= 178.9
Capacity factor	=		= 130.0

Note: 130 is considered the maximum capacity factor

TABLE C

NEW CAPACITY FACTOR RATING	
Required Area	
For caps (705,000/607,730) (160.0)	= 185.7
For downcomer = 0.0064 (2,860 + 579)	= 22.0
For seal	= 22.0
Installed Area	
For caps	= 158.6
For downcomer	= 14.2
For seal	= 14.2
	187.0
Comparison	
Percent of vapor capacity (185.7/158.6)100	= 117.1
Percept of liquid capacity (22.0/14.2)100	= 155.0
Capacity factor	= 130.0

(9) Analysis of calculations

The capacity factor rating of the tray revealed that 33.7 square feet of the tray cross-sectional area was ineffective for both vapor and liquid handling. This loss of approximately 16 percent of the available area is not unusual according to Atkins but more efficient tray layouts have given as much as 90 percent utilization of the tower cross-sectional area. An inspection of the tray layout was made to determine if changes could be made to increase the utilization of the total area. This indicated that additional downcomer area could be obtained without the loss of any cap area by removing pipe type downcomers and installing box type downcomers instead. A new capacity rating was made to show the possible increase in vapor rate at the same liquid rate with this change. See Table C.

This shows an increase in vapor rate of 16 percent at a constant liquid rate. This 16 percent increase in vapor rate would, however, increase the pressure drop across the tray approximately 2.25 inches of hot liquid. This would increase the height of clear liquid in the downcomer to 59.2 percent of the tray spacing plus outlet weir. Past experience with hydrocarbon towers has indicated that vapor is entrained into the downcomer with the liquid reducing the density of the downcomer liquid. This has resulted in downcomers running full with clear liquid heights of 50 to 60 percent of tray spacing. To avoid this new caps were recommended with increased reversal and annular areas, thus reducing the tray pressure drop. The hydraulic gradient is

also reduced some by the installation of the box type downcomers. The downcomer velocity is not excessive at the rates shown in this test and will be reduced further after installation of the new downcomers. The tower superficial velocity is 40 percent greater than design velocities but higher velocities relative to the calculated critical velocity have been obtained without spilling or serious loss in fractionation efficiency.

After the above changes were made, another capacity test was conducted. The data at the incipient spilling point in the top pumparound section for this test are given in Case B of Table 1. Heat and material balances around the tower and around the top two trays were made to check the data and to establish the rates in the tower at the spilling point. These are shown in Tables D and E.

Comparison of Rates—A comparison of internal rates to and from Tray 2 before and after the changes were made are shown in Table F along with the predictions. ##

TABLE F

Stream	Before Changes	After Changes	Percent Increase	Predicted Percent Increase
Liquid from Tray 2	967,500	988,700	2.2	0
Vapor to Tray 2	607,730	703,090	15.7	16

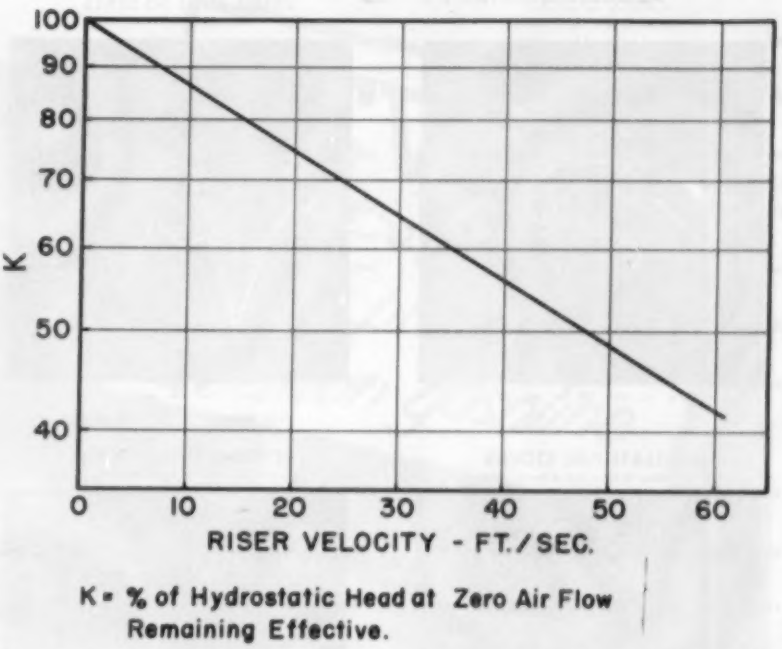

Figure 3. Correlation for predicting hydrostatic head on tray as a function of cap riser velocity.

TABLE D
Over-All Heat and Material Balances

Stream	B/D	°API	Lb./Gal.	Lb./Hr.	Temp. In	Temp. Out	Btu./Lb. In	Btu./Lb. Out	Btu./Hr.
Low Press. Gas	945,000	SCF/Hr.	MW = 39.4	98,200	900	308	822	418	39,673,000
Low Press. Dist.	18,850	53	6.385	210,600	900	308	745	371	78,764,000
Fin. Htg. Oil	12,200	28	7.387	157,700	900	520	709	351	56,457,000
Lt. Cycle Gas Oil	3,000	26	7.481	39,300	900	600	706	404	11,869,000
Hvy. Cycle Gas Oil	3,150	25	7.529	41,500	900	695	705	406	12,409,000
Twr. Btms. Product	2,090	17	7.935	28,900	900	695	690	458	6,705,000
Coke	.....	.....	.....	36,700	.....	.....	.....	.....	.....
Total Products	.....	.....	.....	612,900	.....	.....	.....	.....	.....
Fresh Feed	45,600	25.5	7.505	598,900	.....	.....	.....	.....	.....
Error	.....	.....	.....	14,000	.....	.....	.....	.....	.....
Error, % on Feed	.....	.....	.....	2.34	.....	.....	.....	.....	.....
Steam from Reactor	.....	.....	.....	21,190	900	308	1482	1193	6,124,000
Steam to Tower	.....	.....	.....	1,200	364	308	1195	1193	2,000
Recycle	13,990	17	7.935	194,300	900	695	690	458	45,078,000
Top Circulation	53,700	48	6.563	616,800	182	365	165	271	(65,381,000)
Mid Circulation	3,500	27.7	7.401	45,300	90	538	112	363	(11,370,000)
LCGO Circulation	1,600	26	7.481	20,900	125	600	127	404	(5,789,000)
Bottom Circulation	90,300	17	7.935	1,253,900	503	695	329	458	(161,753,000)
Error	.....	.....	.....	.....	.....	.....	.....	.....	12,788,000
Total Heat Input	.....	.....	.....	.....	.....	.....	.....	.....	257,081,000
Error, % on Heat Input	.....	.....	.....	.....	.....	.....	.....	.....	4.97

TABLE E
Heat and Material Balances Around Top Two Trays

Stream	Lb./Hr.	°API	Temp. In	Temp. Out	Btu./Lb. In	Btu./Lb. Out	Btu./Hr.
Low Press. Gas	98,200	MW=39.4	390	308	462	418	4,321,000
Low Press. Dist.	210,600	53	390	308	413	371	8,845,000
Total Steam	22,390	.....	390	308	1233	1193	896,000
Top Circulation	616,800	48	182	365	165	271	(65,381,000)
Overflow to Tray 3	x	48	390	365	409	271	138(x)
							0

138(x)—51,319,000=0
x=371,900 lb./hr.
Total overflow from Tray 2=988,700 lb./hr.
Total vapor to Tray 2=703,090 lb./hr.

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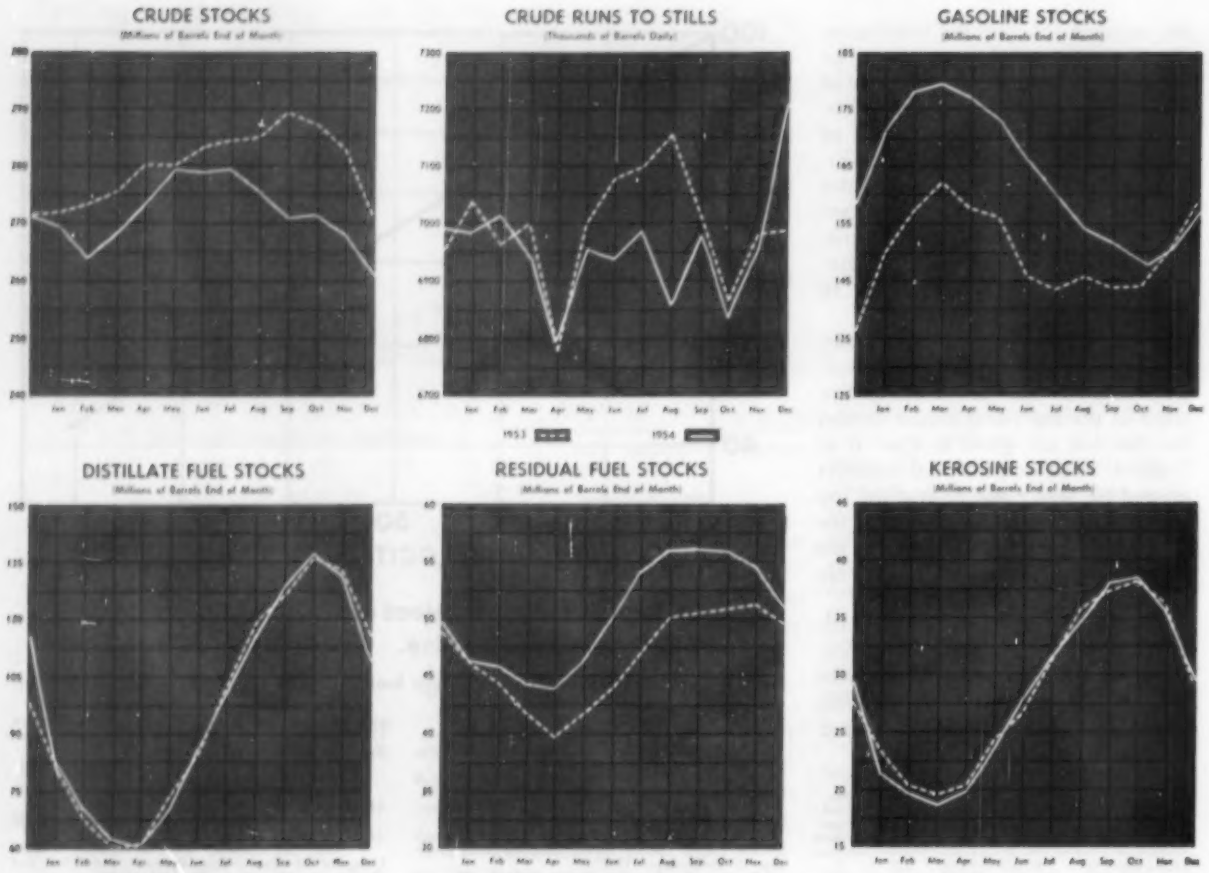

Taking Stock

Cecil W. Smith,
Economics Editor

- Refinery runs at all-time high
- New peak in oil imports reached
- Gasoline stocks under year ago

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1952:													
December	6,634	6,752	271,928	3,361	136,028	421	26,842	1,509	99,582	1,302	48,706	603	1,165
1953:													
January	6,555	7,042	272,250	3,384	150,518	433	23,292	1,528	80,655	1,307	45,910	616	1,135
February	6,562	6,969	273,589	3,379	157,873	404	20,468	1,505	67,167	1,275	44,178	586	1,066
March	6,531	7,002	275,665	3,319	162,731	359	18,697	1,489	59,802	1,256	41,600	655	1,112
April	6,446	6,781	280,487	3,282	158,032	369	20,335	1,424	61,349	1,219	39,572	628	1,010
May	6,390	7,002	280,308	3,366	156,415	327	24,307	1,400	73,706	1,197	41,795	703	1,096
June	6,595	7,081	283,715	3,467	146,196	326	27,659	1,462	84,504	1,238	43,801	707	1,050
July	6,603	7,103	284,976	3,583	143,916	321	31,143	1,441	102,258	1,224	47,530	629	950
August	6,583	7,163	285,352	3,592	146,050	321	35,711	1,437	119,542	1,222	50,007	672	946
September	6,557	7,023	289,614	3,521	144,184	330	37,280	1,448	126,709	1,203	50,516	692	1,013
October	6,262	6,872	287,541	3,437	144,495	355	38,161	1,462	135,409	1,184	50,820	639	990
November	6,277	6,987	283,021	3,528	150,747	354	36,271	1,463	133,381	1,223	51,267	648	1,120
December	6,238	6,964	276,676	3,628	159,949	378	29,070	1,441	111,944	1,247	49,370	598	1,121
1954:													
January	6,240	6,947	270,811	3,431	171,704	390	22,013	1,467	81,044	1,271	47,474	617	1,143
February	6,379	7,068	266,918	3,476	179,950	412	20,183	1,545	70,390	1,241	47,119	621	1,144
March	6,507	6,923	271,867	3,375	181,297	353	17,533	1,458	60,270	1,168	44,249	654	1,088
April	6,615	6,811	280,310	3,404	177,006	322	19,656	1,374	61,721	1,140	44,362	574	950
May	6,471	7,038	282,250	3,482	177,606	302	23,892	1,372	73,581	1,148	47,009	708	1,021
June	6,500	6,947	285,155	3,483	165,404	306	28,184	1,399	86,325	1,123	50,216	624	999
July	6,242	6,916	284,894	3,480	158,010	295	31,953	1,416	101,657	1,089	54,365	724	1,038
August	6,168	6,862	281,043	3,492	153,168	302	34,949	1,453	117,579	1,069	56,332	664	966
September	6,151	6,939	274,608	3,511	150,916	301	37,099	1,514	128,061	1,086	56,702	672	999
October	6,135	6,834	269,442	3,457	149,661	310	37,140	1,545	139,128	1,096	56,541	642	1,065
November	6,246	6,955	267,642	3,408	150,441	346	35,779	1,573	132,925	1,115	54,851	684	1,107
December	6,357	7,203	261,486	3,536	157,228	376	29,281	1,651	109,631	1,138	51,361	701	1,240
Week Ended:													
1-21-55	6,695	7,179	257,705	3,495	166,285	375	26,118	1,751	95,870	1,163	49,831	631	1,106
1-22-54	6,292	7,018	271,009	3,394	165,815	373	23,651	1,504	91,030	1,185	47,247	496	1,089

Source: Data for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

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Meet Our Authors . . .

J. A. Hunter | S. Robert Stiles | George McClure | E. D. Abraham

Carbide Carbon's Hunter Looks at Vacuum Vessel Design

James A. Hunter, Jr., "Save Time in Vacuum Vessel Design," page 100.

James Hunter, project engineer, mechanical engineering group at Carbide and Carbon Chemicals Company, is a native Houstonian and a graduate of Texas A. & M. College. Prior to joining Carbide and Carbon's Works Engineering department in 1950, he had been with Douglas Aircraft Company in El Segundo, Calif. His present duties include teaching a blueprint reading and sketching course for Carbide's apprentice program.

Hunter has written for PETROLEUM REFINER on two previous occasions; "Solve for Vessel Thickness Graphically" was published in July, 1953, and "Solve for Flat Head Thickness Graphically" published in March, 1954.

Stiles Has Run the Gamut in Design Work

S. Robert Stiles, "The Alkylation Process," page 103.

Robert Stiles has been process designer for alkylation isomerization, cat polymerization, distillation, ethylene plants, azeotropic distillation, acid purification, and crystallization processes. At present he is senior process engineer at The M. W. Kellogg Company. He was graduated from Lehigh University in 1934 with a B.S. degree in chemical engineering and later attended Rutgers University. Supplementing his academic efforts in college were his activities in wrestling and cheerleading, two fields of endeavor which may have more in common than most people think.

Abraham and McClure Write From Battelle

E. D. Abraham and G. M. McClure, "How Stresses Affect Branch Connections," page 117.

At Battelle Memorial Institute, Columbus, Ohio, E. D. Abraham is a research engineer in the Applied Mechanics division and G. M. McClure is assistant chief of the division.

Since joining Battelle in 1952, Abraham has been engaged in various theoretical and experimental stress analysis projects. Previously he was with Joy Manufacturing Company. He has a degree in mechanical engineering from Case Institute of Technology.

McClure has an engineering physics degree from Ohio State University. Between his graduation and joining Battelle in 1949, he spent two years in the aircraft industry.

Keeling Earned Degrees And Then Went to Work

Harry J. Keeling, "Save Your Steel Tanks," page 140.

Born in England, Harry J. Keeling moved first to Canada, where he received primary education, and then to Los Angeles, where he attended high school. Continuing his educational efforts, he won a B.S. degree in mechanical engineering from California Institute of Technology in 1929 and an M.S. degree in the same field a year later.

His degrees in his hip pocket, Keeling entered the business world in the form of Southern Counties Gas Company.

He served Southern Counties Gas successively as designer, assistant distributor and mechanical engineer. He left the last position recently to launch his own business as a consulting engineer in Los Angeles.

Authors Have Like Posts At Different Schools

Dwight S. Hoffman and James H. Weber, "Vapor Equilibrium Constants for Benzene," page 137.

Dwight S. Hoffman was born at Leland, Idaho, and is now associate professor of chemical engineering at the University of Idaho, Moscow. In between he has been teaching assistant in general chemistry, instructor in chemical engineering and assis-

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J. L. Tiedje

David Cornell

J. D. Constance

tant professor of chemical engienering, all at Idaho. He holds B.S. and M.S. degrees from the University of Idaho and attended summer sessions at the University of Illinois in 1948 through 1951.

James H. Weber, who was born in Pittsburgh, is associate professor of chemical engineering at the University of Nebraska. He received his B.S., M.S. and PhD. degrees from the University of Pittsburgh. His professional experience includes teaching at Nebraska, summer industrial work and consulting. He is affiliated with a number of technical societies.

Miller Does Research On Du Pont Additives

Charles B. Miller, Jr., "Stability of Shale Oil Gasoline," page 124

As a junior research chemist in the Deepwater, N. J., Petroleum Laboratory of E. I. du Pont de Nemours & Company, Inc., Charles B. Miller does technical service work on additives supplied to the petroleum industry by Du Pont. He has been in his present position since June, 1952.

Miller was born at Wilmington, Del., and received a B. S. degree in chemistry and an M. S. degree in organic chemistry from the University of Delaware in 1951 and 1952, respectively.

Bloch and Wackher Have Near 40 Years in Research

Herman S. Bloch and Richard C. Wackher, "Pure Aromatics from Cracked Naphthas," page 145.

Dr. Herman Bloch is coordinator, Chemicals Research division, Universal Oil Products Company, Riverside, Ill. For the last 19 years he has been associated with research at UOP on various phases of petroleum refining and the development of petroleum products. In his present post, he is coordinating research in the field of petrochemicals. He holds B.S. and Ph.D. degrees from the University of Chicago.

Richard C. Wackher is a research chemist at UOP at Riverside. He was graduated from Washington University at St. Louis in 1928, and has since amassed 20 years of experience in the petroleum research field relating to hydrocarbon conversion reaction and separations.

Laird Well School In Benefits Problem

Lee Laird, "Fringe Benefits Can Break You," page 98

This graduate geologist from the University of Oklahoma has been manager of the Benefits division, Personnel department of Standard Oil Company of California since 1938.

In addition to doing geological work in the western U. S. and old Mexico and leasing work in California early in his career, Lee Laird has been superintendent Land and Lease division, The California Oil Company, in Texas; has done special work for the secretary's office of Standard Oil Company of California, and was assistant secretary of California Standard and various subsidiaries for two years prior to assuming his present position. For 21 years he served as secretary of California Standard's Annuities Committee.

Meet Our Authors. . .

Parish and Cornell Write On Vent Line Design For Refiner Readers

Clyde E. Parish, Jr., and David Cornell, "New Design Method of Vent Lines," page 121

As a research engineer at Eastern States Chemical Company, Clyde Parish is assigned to research and development. Born in Ardmore, Okla., he was graduated from Purdue University, B.S. degree in chemical engineering in 1948, M.S. degree in chemical engineering in 1949. He will receive a PhD. degree from the University of Texas this year. His career includes a two-and-a-half year stint at The Dow Chemical Company as a research and development engineer, and a two-and-a-half year association with the Bureau of Industrial Chemistry at the University of Texas as a research engineer.

David Cornell is an assistant professor in the Department of Chemical Engineering at the University of Texas. Born at Elmira, N. Y., he won all three of his degrees at the University of Michigan: B.S. in chemical engineering in 1947, M.S. in chemical engineering in 1949, and PhD. in 1952. His professional background consists of two years in the Research and Development department at Blaw-Knox Company, two summers with the Texas Petroleum Research Committee, University of Texas, 20 months as electronics technician mate 2/c in the U.S.N.R., and two years as assistant professor at Texas.

Pollock Debates Thermal Cracking of Cat Naphtha

Andre W. Pollock, "Thermal Cracking of Cat Naphtha?," page 127.

Soon after his graduation from Columbia University with a B.S. degree in chemical engineering in 1951, Andre Pollock joined Sun Oil Company. Today he's a research engineer at Sun's Marcus Hook refinery, concerned with process development. The only "sport" in which he participated in college was debate.

Tiedje and MacLeod Work Together on Wax Problems

J. L. Tiedje and D. M. MacLeod, "Higher Ketones as Dewaxing Solvents," page 150

Both J. L. Tiedje and D. M. MacLeod work in the Research department, Imperial Oil Ltd., at Sarnia, Ont., Canada, and spend their time on problems dealing with solvent dewaxing and wax processing.

Tiedje has been with Imperial since 1945. His previous experience was gained at Consolidated Mining and Smelting Company and Pacific Lime Company, both located in British Columbia. He holds B. A. Sc. and M. A. Sc. degrees in chemical engineering from the University of British Columbia.

MacLeod, a Scotsman born at Strathpeffer, has been with the Imperial organization a year. He attended Aberdeen University in Scotland, winning a B.Sc. degree in 1950 and a Ph.D. in 1953.

Brooks and McKetta Give 1-Butene Solubility Data

W. B. Brooks and John J. McKetta, "The Solubility of 1-Butene in Water," page 143.

For the past three years Warren B. Brooks has been senior research technologist at Magnolia Petroleum Company's field research laboratories at Dallas, Texas. In this capacity he has been doing petroleum production research and evaluation of field data. He received a B.S. degree in chemical engineering at Oklahoma A.&M., and M.S. and Ph.D. degrees in chemical engineering at the University of Texas.

The article carrying his by-line in this issue contains much data derived from work on his Ph.D. dissertation, done under the direction of Dr. John J. McKetta, then professor of chemical engineering at Texas and now chairman of the Editorial Committee of PETROLEUM REFINER.

Constance Helps Engineers

John D. Constance, "Engineer's Registration, Why and How," page 179

For the past ten years, John D. Constance has been active in preparing engineers for license examinations in many parts of the U. S. A professional engineer, registered in the States of New York and New Jersey, and holder of the Certificate of Qualification from the National Bureau of Engineering Registration, he has helped many engineers obtain licensure by endorsement with the use of his guidance procedures.

Formerly associated with New York University and ASME in refresher course work, Constance is now with Brooklyn's organization of professional engineers in the same capacity.

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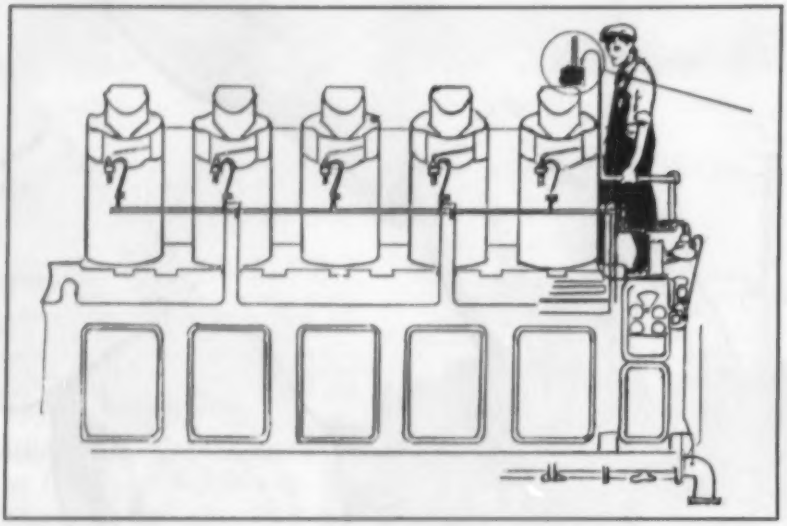
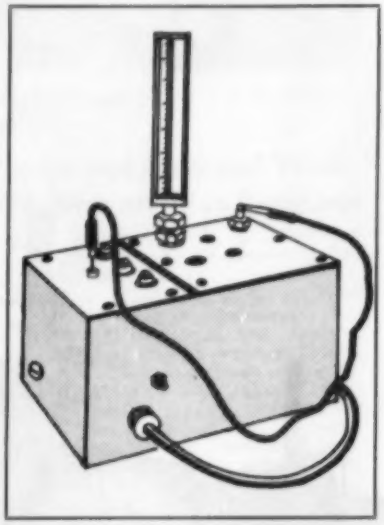
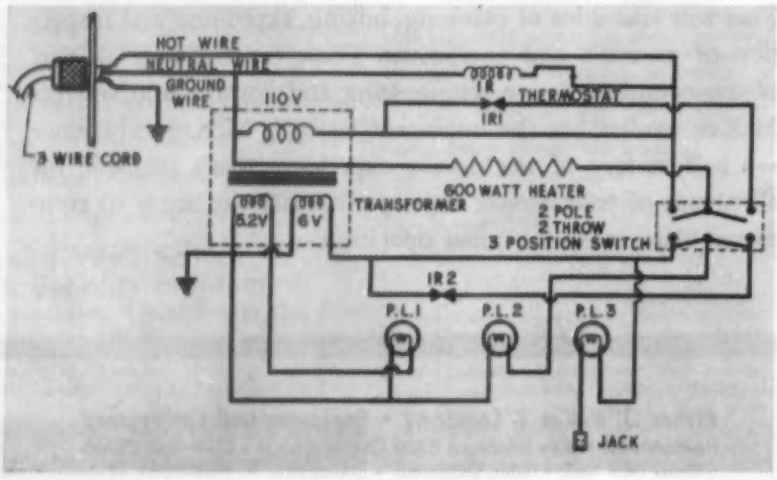




Test Running Engines

Thermostat controls can be checked while the engine is in service by means of this testing device.



A high water temperature safety control testing device for compressor engines allows thermostat controls to be checked while the engine is in service. Heart of the device is a water bath compartment equipped with fittings in the cover to accommodate a thermometer and various types of high water temperature controls.

The bath is heated with a 600-watt submersion heater. A three-position switch allows a selection of "heat-off," "heat on, uncontrolled," and "heat on, thermostatically controlled."

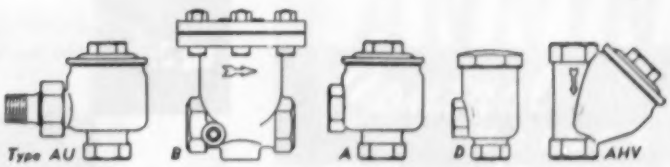
Three indicator lights on the unit are powered by a radio transformer. No. 1 light burns as long as the unit is plugged into a standard 110-volt, 60-cycle outlet; No. 2 light, when the heater is on; and light No. 3, connected with a test lead to the water temperature safety control of the engine being tested, burns when the safety reaches its operating point.

Use of the tester in checking or setting high water temperature controls eliminates the need to raise the entire engine temperature a possible damaging 30 to 40 degrees.

The device provides an accurate and speedy check of thermometers also. The thermometer to be tested is placed in the water bath alongside one of known accuracy and the read-

NICHOLSON Steam Traps'

1. Initial Cost
2. Upkeep Expense
3. Warm-Up Time
4. Production Time



SIX TYPES FOR EVERY PROCESS, HEAT, POWER USE

¼" to 2" sizes for pressures from vacuum to 300 lbs. Bronze, monel or stainless steel bellows. Bronze, semi-steel or cast steel bodies.

SEND FOR TRAP CATALOG 953

W. H. NICHOLSON & CO.

TRAPS · VALVES · FLOATS

207 OREGON ST., WILKES-BARRE, PA.

Sales and Engineering Offices in 53 Principal Cities

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Verti-Line
PUMPS
are made in this new, ultra-modern factory

At Layne & Bowler Pump Company, Verti-Line Turbine Pumps are made to the highest possible standards of quality control . . . In the foundry, iron and bronze castings are poured of metals that are test-proven to be superior . . . In the machine shop every operation must meet the industry's highest inspection standards . . . In the engineering department, every order is reviewed to insure proper selection of a pump that will meet the conditions of the application.

More than 100,000 satisfied vertical pump users agree there's no pump like Verti-Line for low first cost, economical operation, and negligible maintenance.

in the factory

on the farm

for the city

Whatever your vertical pump needs, investigate Verti-Line pumps before you buy.

Send for your free copy of our new booklet, "Pumps For Sale." Ask for Bulletin T-25.

Verti-Line Pumps are the exclusive products of
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How to Do It . . .

ings of the two checked throughout the operating range.

Labor and materials to build the device total about $63.

Light the Right Spot With Inexpensive Support

If you need additional lighting for any area and want to do the job inexpensively, then take a look at this floodlight support. This particular support is mounted atop a pole and provides lighting in four different directions.

The ring shown in the photograph is made from small diameter solid rod. It is slipped over the top of the pole and placed at the desired height. Inside the ring are welded four triangular pieces of sheet metal. Four V-shaped braces run between these triangular pieces of metal and the pole.

Once the ring is in place, lights can be mounted to the ring at the position of the triangular metal pieces. After mounting, the lights can be adjusted so that they cast light where needed. Metal studs welded to the pole enable workers to climb up and replace or adjust the lights.

Outline Gasket Patterns Quickly With Atomizer

An atomizer loaded with chalk dust or talcum powder can be used to make an accurate pattern for cutting

THE VALVE THAT
CONQUERS
FLASHING
CONDENSATES
Better Control, with Lower
Initial and Maintenance Costs
Use Annin valves for better control of steam and condensates to 2500 PSI and 900° F *without* use of hard-to-maintain special assemblies. Flanged seat ring eliminates seal welding. Body construction eliminates liners and reduces down stream piping erosion. Available with manual, cylinder or Domotor automatic operators. Single seat provides bubble-tight shut-off. For better control, longer life, and lower maintenance use ANNIN CONTROL VALVES.
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6570 E. Telegraph Road, Los Angeles 22, California
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VALVES
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VALVES
WRITE TODAY FOR ILLUSTRATED CATALOG 1500 B
You'll profit by learning more about the superior features and better performance of Annin Control Valves.

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Catawissa PERFECT SEAL Unions

HOT FORGED from solid, rectangular steel bars, designed and produced for dependable, long-life service under the severest piping conditions!

A TYPE FOR EVERY USE!
FOR ALL PRESSURES!
FOR ALL TEMPERATURES!

Standard & Double Extra Heavy
UNIONS
Available with screwed or socket weld ends. 3000-lb. sizes ⅛" to 3"; 6000-lb. sizes ⅛" to 2".

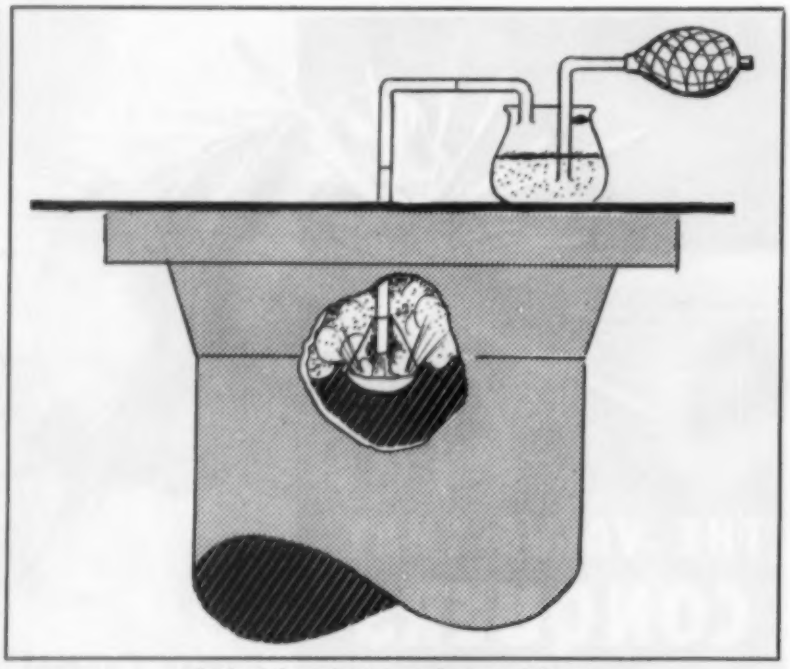
ORIFICE UNIONS
With screwed or socket weld ends. 3000-lb. and 6000-lb. service.

MALE & FEMALE UNIONS
With steel-to-steel, bronze-to-steel, stainless steel-to-steel or orifice seats. 3000-lb. service only.

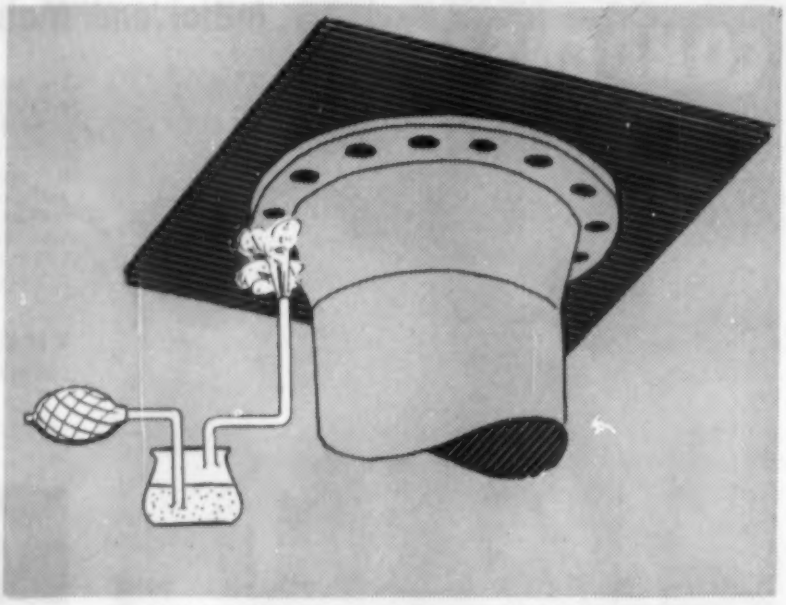
Standard & Double Extra Heavy
LUG NUT UNIONS
Hammer-type for quick opening and quick closing.

WRITE FOR CATALOG 11
showing the complete Catawissa line of Perfect Seal Products

CATAWISSA VALVE AND FITTING COMPANY
25 MILL ST. — CATAWISSA, PA.



Inside of the gasket is sprayed using a deflector.



Bolt holes in the flange are marked very simply with the talc.

How to Do It . . .

gaskets for flanges.

The common practice of hammering a gasket out of material laid over the flange results in inferior gaskets and sometimes in damage to the serrated face of the flange. On the other hand, tracing the pattern with pencil onto the gasket material is difficult and often inaccurate.

Here is an inexpensive method of obtaining the pattern. Simply outfit a dry type atomizer as shown in the illustration. Place the gasket material on top of the flange, and spray the inside of the gasket first, using the deflector as shown in the illustration. After the outside and inside have been marked, cut the gasket from the blank material, using a punch to cut the bolt holes.

YOU'RE PAYING FOR PREHEAT...

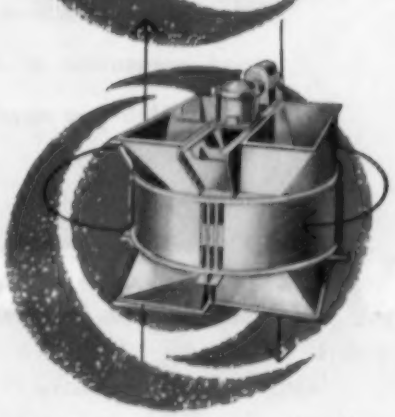
WHY NOT USE IT?

Fuel costs getting you down? In a year or so, a Ljungstrom Air Preheater could pay for itself in fuel savings alone.

Trying to boost your capacity? Four of your present units could do the work of five with Ljungstroms on the job, increasing each unit's output as much as 25%.

Turnaround taking too big a slice out of on-stream time? A Ljungstrom Air Preheater makes fuel burn more completely – at a higher temperature – greatly reducing the rate of slag build-up on furnace tubes. You'll stay on-stream longer – year in and year out – with a Ljungstrom. ®

Our Engineering Staff will be happy to show you how others have saved up to 20% on their annual fuel bills . . . increased throughput as much as 25% . . . reduced slagging and actually improved product octane ratings with Ljungstrom Air Preheaters. Write today for full details.



WHEREVER YOU BURN FUEL, YOU NEED LJUNGSTROM

The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

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YOUR MOTOR FUEL NEEDN'T LOSE ITS PEP . . .

IS WITHIN YOUR GRASP

Blending with Warren NATURAL GASOLINE will give it the RETAINED VOLATILITY so necessary for superior performance after it reaches the fuel tanks of your customers.

Warren's production, transportation and storage facilities are your assurance of the quality and quantity of NATURAL GASOLINE you need . . . when and where you want it.

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Engineers' Registration: Where and How

The trend toward uniformity has eased the task of obtaining licensure. Here's how to go about it.

John D. Constance, Consulting Engineer,
Cliffside Park, N. J.

WITHIN THE next few years industrial organizations will have become much more alert to having registered engineers in their employ. A registered engineer with legal recognition in charge of design will be sure-fire insurance against charges of criminal negligence should failure of equipment cause injury. If an engineer is registered, he has the legal right to do things normally done by engineers, and will be able to fight off the endeavors of other professions to curtail his rightful activities.

How does an engineer go about obtaining licensure? The trend toward uniformity of requirements, except for small differences due to state prerogative, eases the task of applying. The greatest effort will have to be made by those engineers of long experience when writing up their record. Most engineers are too modest in writing this experience and thereby lose much of the effect due to poor documentation. The experience record must give the complete story and must not leave anything to the imagination. The board of examiners cannot read between the lines; it will have to evaluate experience by what is in the record.

The Procedure—The aspirant must write to the secretary of the board or the person officially designated and listed in the addresses provided for this purpose. He should request a set of application forms and a copy of the state registration act. Extra copies of application forms are difficult to get and so it is suggested that care should be exercised to use the form for final format, making preliminary studies on ordinary paper. The statutory requirements will give information as to age, education, experience, citizenship, etc.

The information forwarded to the engineer will help him to decide whether he can meet the basic requirements. Details on writing up the experience record are not given, although the literature will discuss the kind of experience acceptable to the board.

After filling out the various forms, the applicant must be responsible for securing references of the required number and nature listed. These must be persons with registration in the home state of the applicant and personally familiar with the applicant's character, qualifications and experience.

Licensure by Endorsement—Licensure by endorsement (without written examination) is the cherished goal of many engineers with long experience and beyond the age when a written examination is looked upon with relish. The rules cover these requirements to some extent, but it is solely within the discretionary powers of the board of examiners after carefully weighing the experience record and the references produced. Years of eminent practice or outstanding achievements weigh heavily in the applicant's favor. Most state boards have adopted criteria by which to evaluate professional standing. These include advanced studies, higher degrees, technical society activities, contributions to engineering knowledge and progress, inventions and patents, technical publications, high regard and esteem by fellow engineers, important developments and achievements, and prior registration in another state.

The mere showing of 12 to 15 calendar years of experience is insufficient to qualify an applicant for exemption from the written examination. Many boards, however, recognize that years of outstanding experience and achievements are far better evidence of qualification than are the results of written examinations.

Written Examination—It is recommended from personal experience that the applicant first determine if he is qualified to take the written examination or, if he so qualifies, apply for licensure by endorsement before plunging into the matter of refresher courses or home study preparation. His own board of examiners alone are in the position to do this, although a good knowledge of filing procedure will be of great value.

The applicant, after successfully becoming a candidate, should investigate places where refresher courses are offered; or, if he finds it inconvenient to attend these courses, to seek advice or information as to a course of home study.

Local chapters of the various state societies of professional engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Society of Civil Engineers, American Society of Tool Engineers, Western Society of Engineers, Detroit Engineering Society and many other organizations have set up refresher courses. A candidate may contact any of the local branches or write directly to his board secretary for information. Some employers are providing their engineering personnel with tuition-free courses as a part of their professional development program.

Engineer-in-Training—The license laws in many states provide for the certification of engineer-in-training classification prior to obtaining full licensure. Machinery has been set up for the reciprocal recognition of Engineers-in-Training (E.I.T.) and thus paves the way for the early development of professional consciousness among engineers. The examinations in the various states are so organized that the man with an engineering degree from an accredited school of engineering, and the man with the minimum educational requirement of graduation from high school plus eight

See ENGINEERS, Page 193

Make the Most of Your Meetings

Is your company getting maximum benefit from conferences? Perhaps you should put greater stress on readiness, participation, action.

Irving Ladimer,
Washington, D. C.

THE PRIME PARADOX in American free enterprise is that *individual* initiative is made and managed by *group* action, group thinking. Gone are the days of the lone operator, even the individual inventor or attic scientist.

Working together and using the experience and example of many is a significant modern phenomenon, influencing the business world as it traditionally has molded activity in the professions, in the sciences, in governmental relations. The meeting, whether it be the committee or the convention, has become the accepted voluntary way of getting to know not only **who** (once considered to be the only payoff in business) but **what.**

American business grumbles and gripes at attending conclaves and confabs which eat into time, expense accounts and ulcers but would no more think of jettisoning this freight than giving up advertising and promotion.

The annual round of conventions, usually beginning in September, comes to about 75,000, according to the Federal Commerce Department. More than 12,000 are yearly meetings of industry associations, trade shows or conventions of professional organizations in business and commerce. Another 60,000 are company conventions of some size. Around 6 million a year attend these company get-togethers, including an increasing number of repeaters who show up at several a year.

By accepting conference attendance as serious business, it is only sensible to get the maximum benefit to the firm, the industry and to our economy generally. Some firms also have invested in full-time conventioneers, but most prefer to select executives suitable to the occasion. After all, they may want to see what's going on, and — of more importance — others want to see them, rather than the professional agent who is less likely to know or direct company policy.

What You Can Do . . .

To make the difference between a dud and a dynamic leader at a conference which calls for group action—

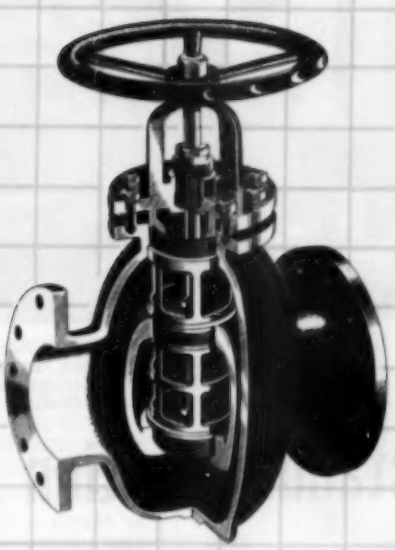
- Think. Contribute creatively to the action of your group.
- Encourage others—particularly the shy—to speak, accept jobs.
- Be objective, simple, brief in speaking and acting. Get to the core of the problem.
- Be loyal to the group. Serve it, not your personal interest.
- Be a team member. Help dislodge jealousy, destructive competition.
- Help establish a climate for free discussion, acceptance of ideas, translation into action.
- Listen. Accept proposals objectively, evaluate critically but positively.
- Show enthusiasm and support good ideas, wherever they come from.
- Introduce and follow system in discussion, action, evaluation.
- Keep on the track and guide others along the straight paths.

—adapted from *My Group and I* by Lippitt and Schmidt

Is It Necessary?—Let us begin from the beginning. In the case of a conference, that's well before the opening dates. It is assumed (perhaps without justification in some cases) that there is a definite need and purpose for the meeting. Other than the values of meeting new people, keeping up acquaintanceships, shopping for trade gossip, there should be primary goals evident. An industry may be faced with governmental restrictions or conversely, government demands for expansion; the threat of foreign competition; the problem of keeping pace with the general economy; acute specialized manpower shortages. A company at its annual convention may have specific problems which underlie sales issues: other-industry inroads, geographic market changes, technological impasses. It is important to know why the meeting will be held and to prepare for it.

Pre-Conference readiness should include assigning to those who will attend the job of intelligent two-way representation. On the basis of study of the conference agenda and its aims, executives and staff must present themselves as knowledgeable as well as personable ambassadors for their organizations. At the same time, they serve as eyes, ears and interpreters for those who remain at headquarters.

If a contingent is going, the latter function may be farmed out along lines of interest or responsibility. Not unusual is the detailing of day-by-day



No seat — consequently no regrinding.

Can be serviced in the line.

Unaffected by wiredrawing.

Unaffected by throttled use.

Design Tells...

THE KLINGER SEATLESS PISTON VALVE operates on an entirely different principle from the usual type of seating valve. It consists basically of a finely ground piston, operated by the valve spindle and hand-wheel and moving through two or three non-metallic, resilient valve rings, capable of resisting steam, oil and most fluids, at high temperatures and pressures and separated by a ported lantern bush. It is made in a great variety of designs and sizes to suit all purposes.

Write for the Klinger Master Catalog which describes the complete range of Klinger products.

WITH *Klinger* SEATLESS PISTON VALVES

RICHARD KLINGER LIMITED, KLINGERIT WORKS, SIDCUP, KENT, ENGLAND

Cables: Klingerit **Agents throughout the world** **Telephone: Foots Cray 3022**

MANUFACTURERS OF KLINGER SEATLESS PISTON VALVES; KLINGER SLEEVE-PACKED COCKS; KLINGER LEVEL INDICATORS; RINGS AND SEALS IN KLINGER SYNTHETIC MATERIALS, AND KLINGERIT COMPRESSED ASBESTOS SHEET JOINTINGS AND PACKINGS FOR EVERY PURPOSE

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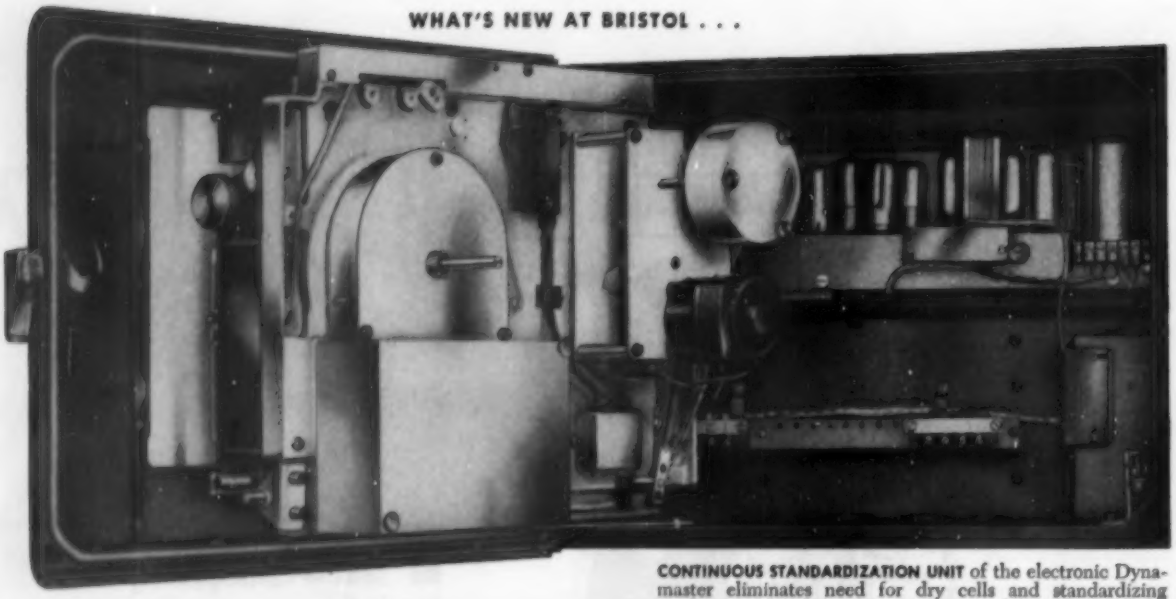
WHAT'S NEW AT BRISTOL . . .



CONTINUOUS STANDARDIZATION UNIT of the electronic Dynamaster eliminates need for dry cells and standardizing mechanism. Result: no interruptions in the operation of the potentiometer for standardization; no batteries to replace.

No time out for standardization here

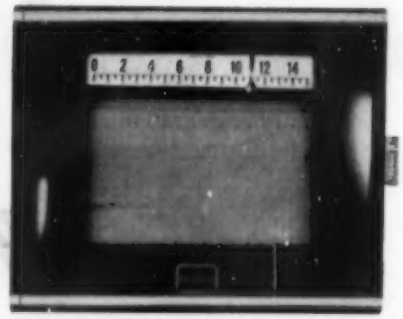
Bristol Dynamaster potentiometer pyrometers give you No-Batt continuous standardization

• You don't have to put up with interrupted performance from old-fashioned potentiometer pyrometers any longer!

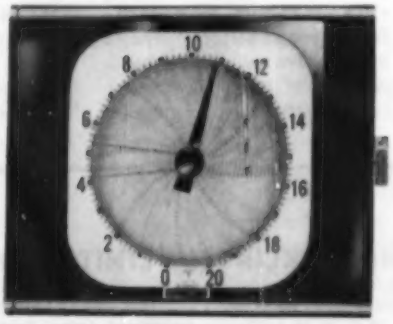
When you use a Bristol thermocouple or radiation-type Dynamaster, you get a *continuous* record or control of temperatures up to 4000°F in any type of fuel-fired or electric furnace or heating equipment. Thanks to the exclusive No-Batt continuous standardization which eliminates the need for dry cells in these electronic instruments, Bristol has been able to do away with interruptions formerly required for periodic standardization.

Bristol electronic Dynamasters are made in round- and strip-chart, single- and multiple-record recorders, air-operated and electric controllers with all types of control actions. Two-pen and program control.

For the complete story on the modern human-engineered Bristol Dynamaster, write for free 35-page booklet P1245. The Bristol Company, 111 Bristol Road, Waterbury 20, Conn.



BRISTOL DYNAMASTER CONTROLLERS in either the strip-chart model (shown above) or round-chart model, may be electrically or air operated. 2 position, 3 position, proportional, manual with automatic reset, or proportional input controls. On - off, proportional or reset air controls.



BRISTOL DYNAMASTER RECORDERS come in easy-to-read round-chart (shown here) or strip-chart models. Single record, multiple record or continuous 2 record designs are available. Bristol also supplies all types of time-temperature program controllers.

BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more data on advertised products, use Readers' Service Cards, last page.

orders to attend sessions, meet customers, fill in at the local office, file reports and act as host. This careful programming utilizes the full potential of each delegate . . . but overplanning may fail to permit the flexibility and rapid change which may be needed at an active gathering. Send sound, experienced men with good judgment and firm loyalty rather than second-raters with a train schedule.

At-conference participation obviously includes attendance or coverage of the main work sessions and committee actions. There is no substitute for on-the-spot listening and study of both speaker and audience. Even though the major addresses may be reprinted and available for later analysis, the delivery and immediate reactions of interest, surprise or disbelief cannot be captured from a stale report. If the convention uses operating committees, post-meeting studies and surveys as a means of linking annual sessions, steering and executive staffs for special problems, actual and not vicarious participation is imperative. Place your men on committees, have them ask questions and get answers, let them use all the facilities of group action and consideration to bring back information, trends, ideas.

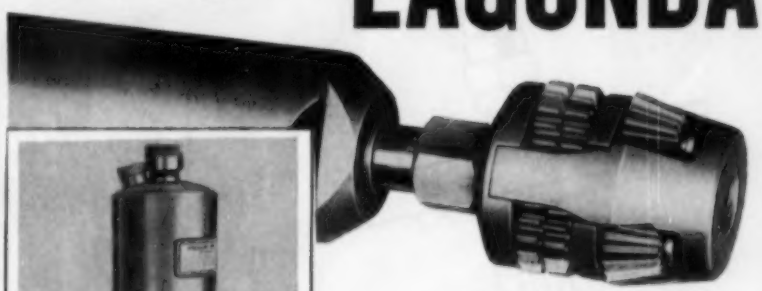
Taking part also means keeping a finger on the conference pulse. Simply speaking, each representative should have an awareness of how things are going—where the lags are or may be coming; what changes should be made, in midstream if necessary, to clinch a resolution or decision; what reports are due. He must equally judge where stress and strain can be relaxed because things are well in hand. This kind of super-level participation calls for a conscious responsibility for getting things done and formulating plans for post-conference action.

Post-conference action is often neglected, though this is the payoff post. After all is said, there's work to be done. In general, three kinds of intelligence ought to be brought back from the conference front, as quickly as possible:

• Facts and figures presented at the meeting by outside specialists, industry or company men and col-

When Operators growl

...TRY LAGONDA



The famous Lagonda 1100 Series refinery cleaner, with the Type UO head. This combination is tough on coke.

AUTOMATIC SIGHT FEED LUBRICATOR controlled entirely by pressure. Simple and positive.

FOR CONDENSER AND HEAT EXCHANGER TUBES. Direct-drive air driven cleaner with long shaft, the motor supported outside the tube by overhead pipe. Motor has trigger control. Also available with electric motor.

CATALYST CLEANER. Removes spent catalyst from tubes, without permitting its escape.

Tube cleaning is a trying chore. You can't blame operators for getting sore at tools that make an uphill job of it, particularly if breakage occurs too often. Nor can you blame operators for trying, when a variety of tools are available, to get the Lagonda cleaner for their personal use. Sometimes an operator will "bunk" his Lagonda cleaner over the lunch-hour, making sure he'll get it again to finish the job. Just about the strongest recommendation a tool could have. To keep operators happy, and get stills back on stream quick, try Lagonda. Check with your nearby Lagonda man before your next cleanout. He can save you valuable time. Or write Elliott Company, Lagonda Division, Springfield, Ohio to put you in touch.

ELLIOTT Company

Y4-4

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

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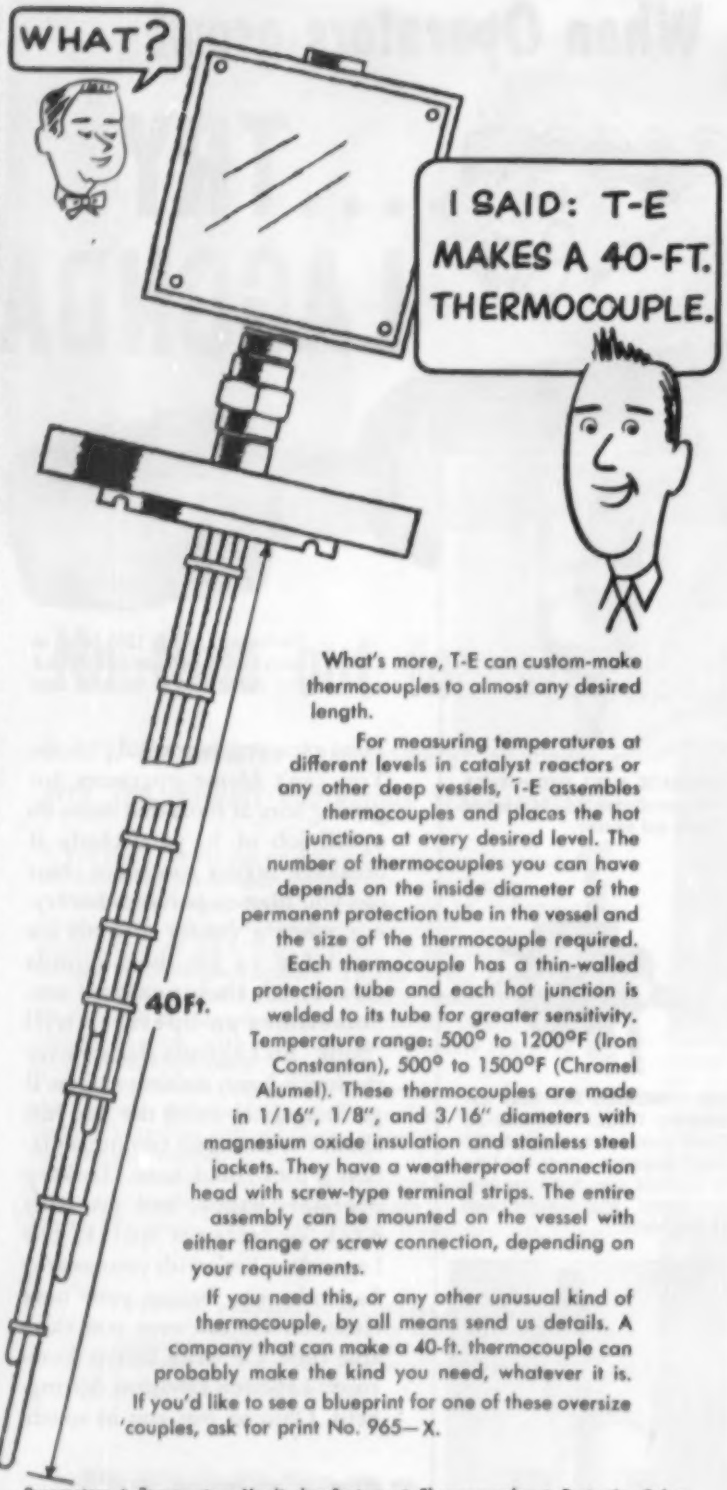


What's more, T-E can custom-make thermocouples to almost any desired length.

For measuring temperatures at different levels in catalyst reactors or any other deep vessels, T-E assembles thermocouples and places the hot junctions at every desired level. The number of thermocouples you can have depends on the inside diameter of the permanent protection tube in the vessel and the size of the thermocouple required. Each thermocouple has a thin-walled protection tube and each hot junction is welded to its tube for greater sensitivity. Temperature range: 500° to 1200°F (Iron Constantan), 500° to 1500°F (Chromel Alumel). These thermocouples are made in 1/16", 1/8", and 3/16" diameters with magnesium oxide insulation and stainless steel jackets. They have a weatherproof connection head with screw-type terminal strips. The entire assembly can be mounted on the vessel with either flange or screw connection, depending on your requirements.

If you need this, or any other unusual kind of thermocouple, by all means send us details. A company that can make a 40-ft. thermocouple can probably make the kind you need, whatever it is.

If you'd like to see a blueprint for one of these oversize 'couples, ask for print No. 965—X.

Pyrometers • Temperature Monitoring Systems • Thermocouples • Protection Tubes
Quick-Coupling Connectors and Panels • Thermocouple and Extension Wires

Thermo Electric Co., Inc.

SADDLE RIVER TOWNSHIP, ROCHELLE PARK POST OFFICE, NEW JERSEY
IN CANADA—THERMO ELECTRIC (Canada) Ltd., BRAMPTON, ONTARIO

As Management Sees It . . .

leagues from other firms.

• Impressions made, sales and contacts developed and leads to be run down by the firm.

• Evaluation and analysis of the meeting in terms of the particular issues facing the company.

A written report with appropriate underscorings for levels of management and departments, often demanded, is unquestionably desirable as a record for the future as well as of the past. It is a basis of action and planning.

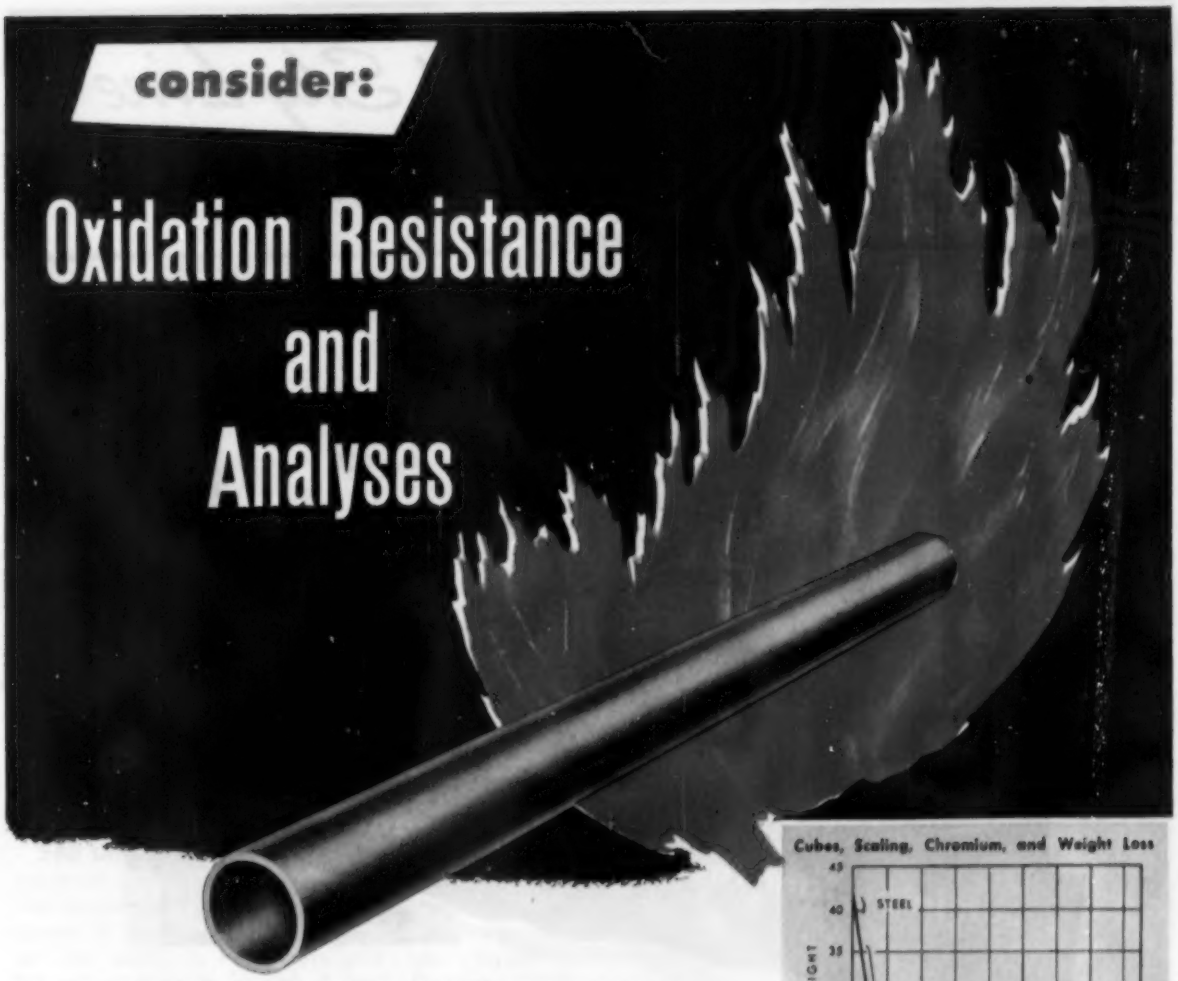
A final aspect of the post-mortem should, as for royalty, hail the new as well as bewail the deceased. While the conference is still fresh in mind, ideas for the next agenda should be put into the hopper. If the meeting is to develop a program, and especially if each delegate is expected to help as well as hear, it is essential to begin thinking about the next go-round as early as possible.

Methods and Gimmicks—Conference planners and arrangers of the modern school are evident today, selling methods and gimmicks to make the convention move, the committee tick. Where beauties emerged from a frosted cake, now intricate mobiles, exhibits using appeals to all the senses and gadgets of all types are employed to snare attention. On the more serious level, however, the best of today's technology has been applied. Outstanding perhaps is the use of closed-circuit TV which allows simultaneous presentation to hotel rooms scattered over a city, and two-way hookups, right from the boss' office in the plant. Color will probably be used soon. The diorama and the moving model, largely used for scientific and professional display in the past, are now standard props in booths.

With all the best of electronics, art and movies, the surest method of achieving success is hard work in the tested techniques of sitting and seeing alertly. The conference must be regarded seriously and used fully, more as an informational and educational medium than a social whirl. Big money goes into meetings and, carefully invested, can yield considerable profit. ##

consider:

Oxidation Resistance and Analyses

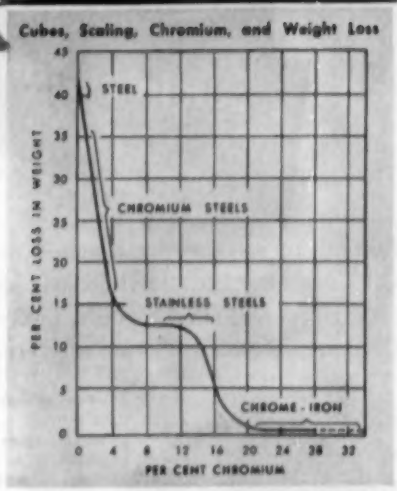


The loss of metal, through scaling, at high temperatures is a costly phenomenon that must be considered in the selection of stainless tubing where conditions of extended excessive temperatures are present.

When choosing a specific Croloy for your operation it is well to review the factors that govern the service life of the tube. For example, B&W Croloy 18-8S (AISI Type 304) can operate, without excessive scaling, at a maximum temperature of 1650 F. Here, as in most other cases, the temperature limit may have to be revised downward should combustion products or gases high in sulphur compounds or vanadium-containing ash be present.

This is but one general example of the intricacies involved in choosing the proper stainless tubing for a specific use. For virtually any application B&W can provide either seamless or welded stainless tubing in any number of grades, in a broad size range. Help in obtaining the best stainless tubing —pressure or mechanical—for your applications is available through B&W Regional Sales Offices and a nationwide network of experienced tubing distributors. Mr. Tubes—your link to B&W—will be pleased to furnish detailed answers to your stainless tubing problems.

TA-4050(55M)



Many tests have been made under different temperatures with steels having various chromium content to determine their resistance to oxidation. Chart above clearly explains what happens — oxidationwise —to metals when exposed to a temperature of 1835 F for 48 hours.

B&W STAINLESS and WELDED TUBES

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION

Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
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Addition to the 1954 Sky Line

NEW CAT-POLY UNIT for SOCONY-VACUUM

Recently turned over to the owners, Socony-Vacuum Oil Company, Inc., this modern phosphoric acid catalytic polymerization unit, under license from California Research Corporation, is currently producing high octane gasoline. Our engineering staff was responsible for complete design and erection.

This completion and the accompanying list of other current projects, will serve to emphasize the scope of our engineering service. It is as broad a service as the client wishes to utilize, including preliminary economic studies and competing process evaluations. It covers complete plants as well as processing units in the petroleum, petrochemical and chemical fields.

Should you assign us to work on *your* problem we would focus many years of engineering experience in the design of such processing plants and units plus the complementing experience of other important engineering services such as mechanical, electrical, structural, power and instrumentation.

Engineering

Design and Construction of Process Plants

•

Design and Construction of Process Units

•

Process Evaluations

•

Economic Studies

Other projects either recently completed or in advanced phases of design or construction include:

- Aromatics Recovery from Petroleum Stocks
- Separation of Para Xylene
- Synthetic Methanol and Ethanol Refining
- Naphthalene Purification
- Recovery of Acetic Acid
- Gasoline Treating
- Refinery Modernization

BADGER MANUFACTURING COMPANY

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In the Oil Industry . . .

Credit Unions Are Big Business

With its 298 groups oil ranks second only to federal government in credit union activity.

George N. Hebert,
Lake Charles, La.

THIRTY MILLION dollars is a lot of money . . . you bet it is! And, that is exactly how much credit union members saved in interest last year alone, by borrowing from an organization operated by amateur financiers who, as a group, represent every stratum of American society.

Credit unions are divided into three groups: Associational, Occupational, and Residential. In the Occupational grouping there are 51 subdivisions which include all phases of business, educational and governmental activity. The petroleum industry ranks second only to the federal government in credit union activity.

298 Unions—Oil company employes are among the 6 million people who are members of the 14,000 credit unions in the Western Hemisphere and who would—in 1953—have paid $30 million more in interest if they had no credit unions from which to borrow.

There are 298 operating credit unions in the petroleum industry. They have a total asset listing of $59,194,074. Their gross income in 1953 amounted to $3,948,471 and from this amount they paid $1,882,661 in dividends to shareholders.

The credit union policy so aptly phrased in its slogan, "Not charity, but service," has made a great contribution to the field of person financing.

A credit union is a group of people with a common bond of association—coteries of industrial workers, of farmers, of lodge and church groups, of urban communities — who pool their savings and lend to each other at a low rate of interest. It is completely owned and operated by members, for the members, and is subsidized by the government to the extent that its revenues are not taxable.

Here, the resemblance to a socialized business stops.

Founded by William Henry Raiffeisen in the country town of Flammersfeld, Germany over 100 years ago to combat the usury of money lenders, credit unions have fulfilled their dedication. Raiffeisen's main idea was that only people who belonged to the credit union could borrow from it; second, that loans would be made only for provident and productive purposes, at low interest, and, third, that a man's character was the most important security for his loan. He insisted that all people in the credit union have a common bond of interest to hold them together.

Credit unions are still operating on these basic principles.

Popular Method—Testimony to their effectiveness is found in last year's records of loan business done. Petroleum industry credit unions made a total of 85,654 loans which averaged $534 each. Of these, only 4583 were reported delinquent. The federal government made a total of 172,434 loans averaging $345 apiece and had 21,573 reported delinquent.

Business and industrial management has generally encouraged the organization of credit unions. The major obstacle to credit union popularity in business was the debated advisability of establishing one within a company because it had the effect of competing with banks and other reputable financial institutions in the community. The realization was soon coming that the functions of a credit union do not replace financial institutions. It actually helps them. The employe organization has filled a need with members that could not have been met in any other way. It has developed a savings habit which would not, in many instances, have previously existed. These savings have been used wisely to help the employe

in the petrochemical industry
"HEAT EXCHANGERS BY Paracoil"
is a WELL KNOWN and RESPECTED "BY-LINE"
It means specialized experience in the fabrication of completely integrated heat exchanger units that are
Dependable in performance . . .
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For many years we have been building
Solvent Recovery Equipment
Extraction Coils
Evaporators
Reaction Vessels
Condensers (for any Vapor)
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Exhaust Waste Heat Boilers
Quenching Oil Coolers
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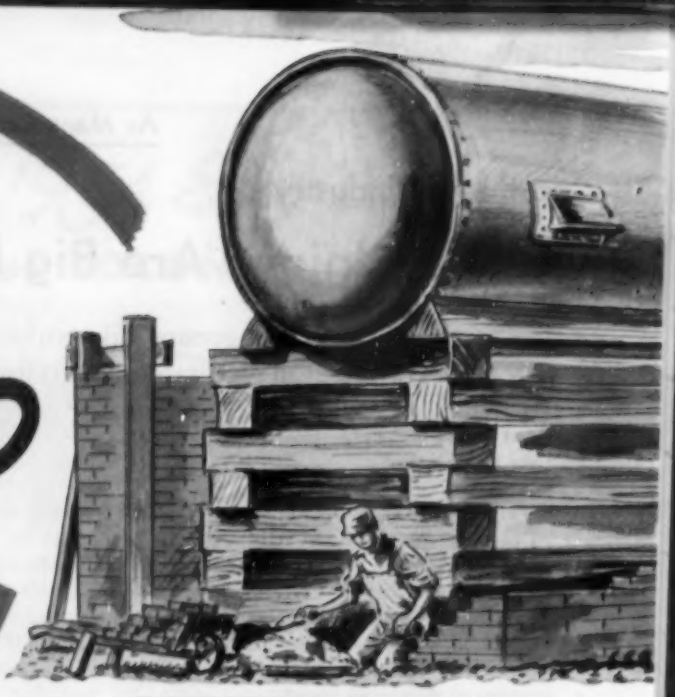
For more data on advertised products, use Readers' Service Cards, last page.

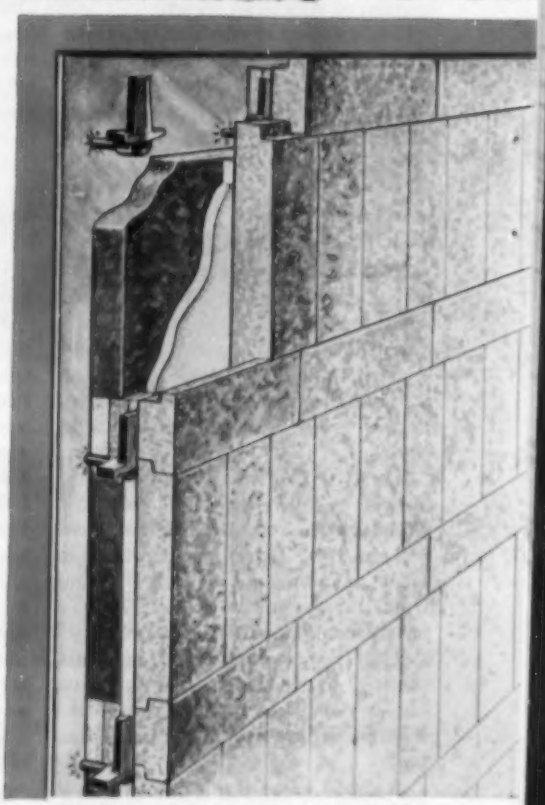
WHEN HEAT MUST BE ENCLOSED



In the old days some grate bars and a brick wall were the prime materials needed for a heat enclosure. Today industry demands higher temperatures, lower heat loss and greater efficiency.

And how can this be accomplished? By the selection of correct material, — a design that comes from experience, — responsibility for correct application. And where can you get this combination? Only from heat enclosure headquarters — DETRICK.

It was DETRICK who first put a suspended arch in a furnace. It was DETRICK that first sectionalized and supported furnace walls. It was DETRICK that developed the composite wall that supported refractory, insulation and a sealing layer in one unit. It was DETRICK that forced the development of materials that meet the demands of today's heat enclosures. For 42 years DETRICK has led the way. Their's is the responsibility of leadership.



THERMOLAYER CONSTRUCTION — A typical Detrick design providing speedily erected protection for steel encased units of any contour involving refractory for heat protection, insulation for holding heat and a sealing layer for tightness.

SEND FOR CATALOG

For more detailed information on this subject send for our booklet entitled "HEAT ENCLOSURE METHODS by DETRICK". If it's a problem of enclosing heat it's a job for DETRICK.

M. H. DETRICK COMPANY
111 W. Washington St. Chicago 2, Ill.

DETRICK Heat ENCLOSURES

DETRICK
HEAT ENCLOSURES

when loans were needed. Because of this, employes have kept themselves in better financial condition than they would have done overwise, thus making it possible for them to borrow larger sums from banks.

Other opinions from top management were listed recently in *The Credit Union Bridge*, the organization's national publication. Among those offering these opinions were representatives of the oil business.

- Credit unions provide an easy, sound, "painless" way to save money. Management's experience has been that a man with savings is a better and happier employe. Certainly there is no more "painless" way to save money than through payroll deductions . . . a system permitted by the majority of petroleum companies.
- A sound, fast and friendly way to borrow.
- Reduces the necessity for salary advances.
- Exposes many people to management problems. Committees, membership, officers, who must handle their own administrative problems to the satisfaction of the group.
- Reduces attachments and garnishments.
- Contributes to the building of a better organization.

For many years management has been conscious of people's importance to the success of any business. It believes that a credit union—by its own independence—is one of the vehicles through which management can demonstrate its recognition of the importance of the individual worker.

One proof of management attitude is the fact that many oil companies have contributed financially toward the success of their credit unions. Others contribute furnishings, office space, supplies, free clerical labor and permit payroll deduction.

Not Taxable—Credit union funds are not taxable and they are managed by volunteers. This, combined with low expenses and the bond of membership which permits loans without investigation fees and collection costs, makes it possible to lend money at an interest rate of 1 percent on the unpaid balance. The low cost makes credit available to many people who could not under ordinary

Send for new information on R-C Rotary Positive Blowers

CHECK THE "BIG 4" ESSENTIALS

1. Accurate volume at required pressure
2. High efficiency—low operating cost
3. Low maintenance cost —low down time
4. Freedom from oil or oil vapor contamination

Check your present blowers and if they don't measure up, it may be an economy to replace them with modern R-C equipment.

For your present needs, or for future reference, you'll find highly useful information on the smaller sizes of Roots-Connersville Rotary Positive Blowers in this new Bulletin No. AF-154.

Especially important are the tables showing sizes, pressures, capacities and other characteristics to help you select blowers for specific applications.

You'll also find included factual data which points out why R-C Blowers meet the "BIG 4" essentials of successful performance.

If your files are not complete on other Roots-Connersville equipment for handling air and gas, ask for bulletins on:

Centrifugal Blowers and Exhausters . . 120-B-14
Positive Displacement Meters . . M-152
Gas Pumps (small) 31-B-17
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Vacuum Pumps 50-B-13
Inert Gas Generators 100-B-14
Rotary Positive Blowers (large sizes) . . RB-254

For any problem of handling gas or air, consult Roots-Connersville, now in their second century of building such equipment, exclusively.

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A DIVISION OF DRESSER INDUSTRIES, INC.
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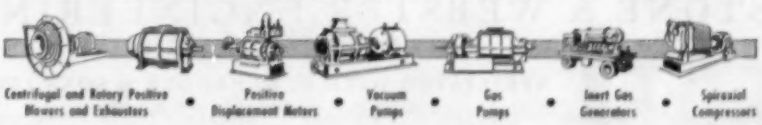

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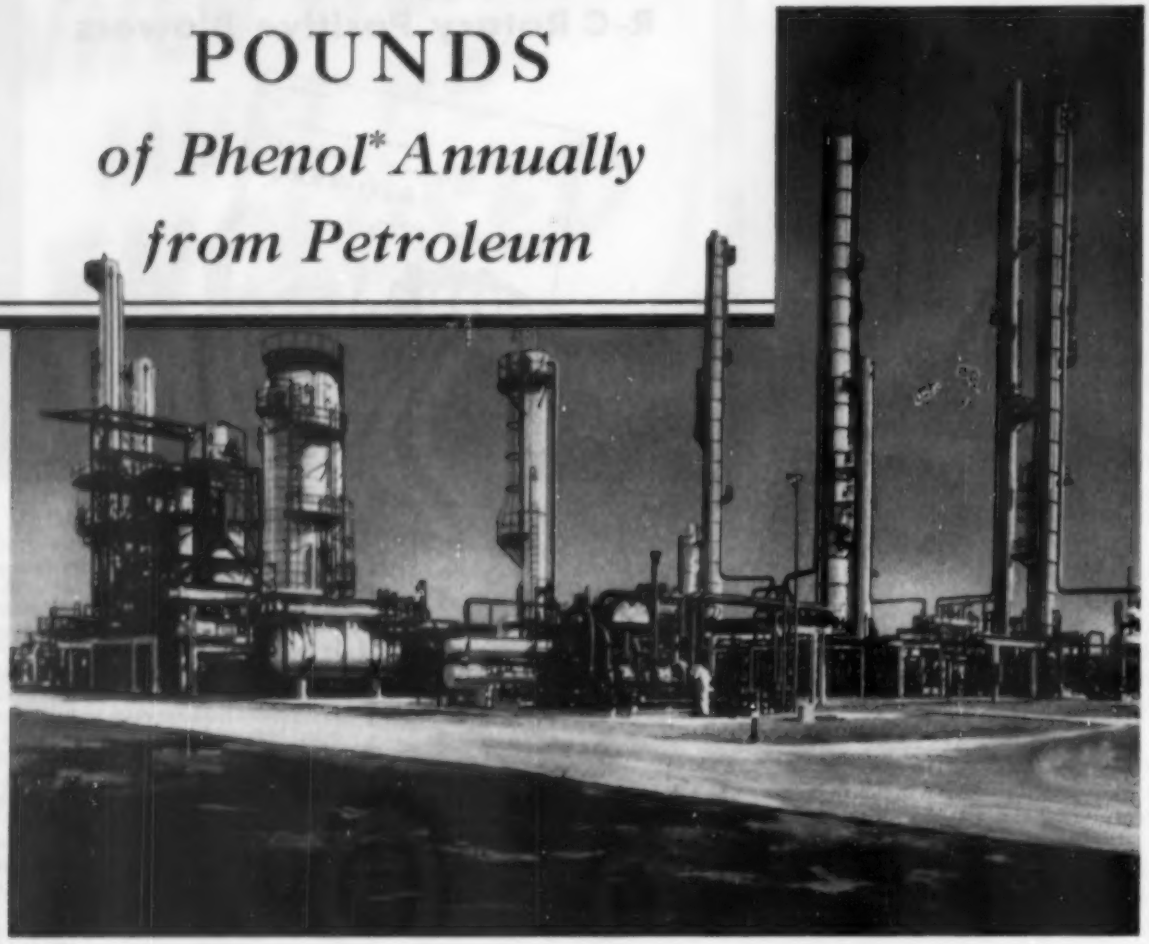
of Phenol Annually from Petroleum*

**"Phenol" is one of today's "Big Three" in chemicals—a base material for the expanding plastics industry.*



Standard Oil Company of California now is making pure phenol and acetone from cumene by a new process at its Richmond, California Refinery under license from Hercules Powder Company.

Acting as Process Consultants and Constructors, Stone & Webster Engineering Corporation worked closely with the engineers of Standard Oil, who prepared the process and mechanical designs. The plant was completed ahead of schedule and operated in excess of rated capacity.

Write or call us for information as to how our experience may be of assistance to you.

STONE & WEBSTER ENGINEERING CORPORATION

BADGER PROCESS DIVISION

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circumstances afford to borrow.

In the petroleum industry's 298 Federal Credit Unions, members are eager to take advantage of the low interest rate. Until 1953, oil company credit unions had loaned $338,931,-014 to their members. Savings in interest if computed on a comparative basis would be staggering.

Dividends are gaged by credit union income. Maximum dividend rate is 6 percent, and many of the organizations maintain this maximum making credit union shares a fine investment for the working man.

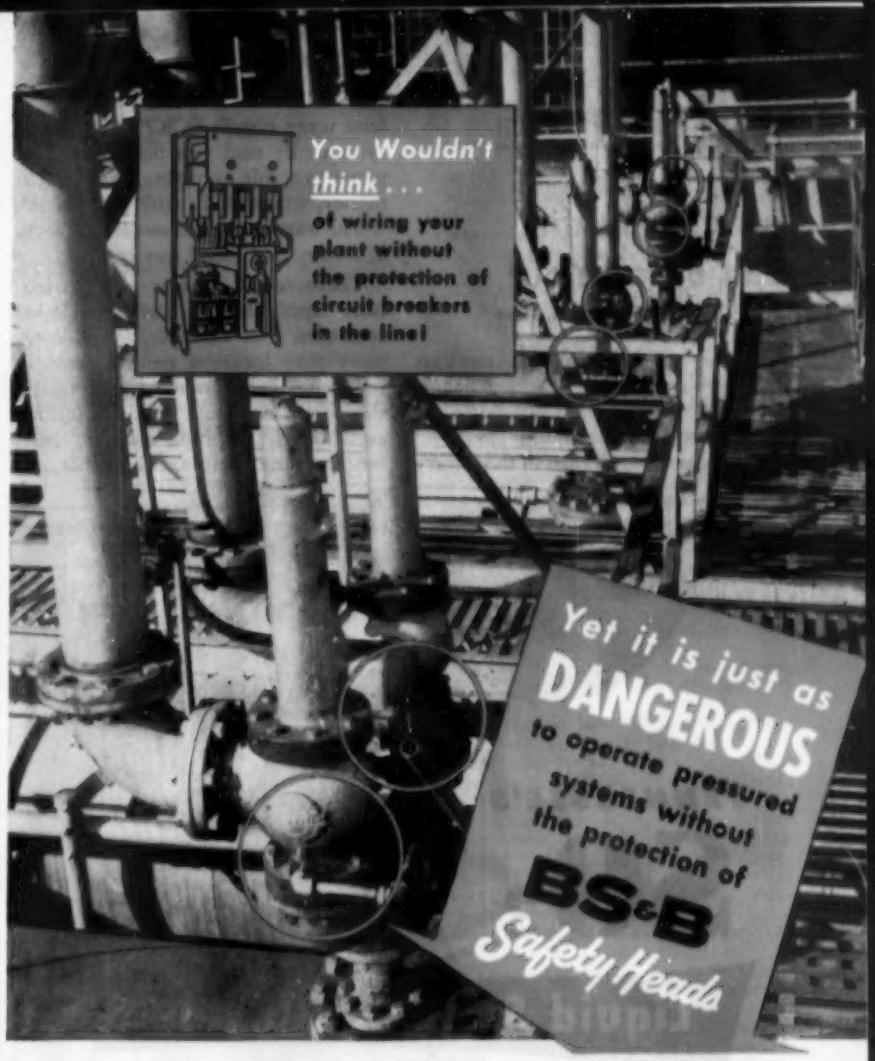
To join a credit union and to be eligible to borrow it is necessary to purchase one share in the amount of $5. In many small plants this fee is collected piecemeal. Once the applicant has signed a promise to buy one share he is eligible for credit.

Although a member of one credit union cannot transact business with another credit union on his original membership, he can continue making deposits to the organization of which he is a member.

Side by side with the above mentioned benefits and attributes of these organizations is another indication of their anti-socialistic contributions to the promotion of free enterprise. Each member of the credit union has one vote, regardless of how much stock he owns or how much business his credit union does for him. The one-man, one-vote idea is truly representative of the democracy these organizations serve.

To look back on the contribution made by the American who brought credit unions to this country is to find devotion to the principles of enterprise at its best.

Edward A. Filene, a millionaire Boston merchant and a practical business man, was the first American to find the idealistic, self-help credit union plan workable and sound. His faith was proved when he invested his entire personal fortune to advance the idea. And this, at a time when there were no laws under which credit unions could operate, no chapters and very little public interest. Filene's vision, his unswerving ambition, took an idea and built a mighty movement for but one reason—that of accomplishing a purpose for the common good of it. ##


You Wouldn't think . . .
of wiring your plant without the protection of circuit breakers in the line!
Yet it is just as DANGEROUS to operate pressured systems without the protection of
BS&B
Safety Heads

Just as an electrical circuit breaker protects your personnel, plant and equipment from electrical overloads, shorts and "burn-outs", so does the BS&B Safety Head protect them from the dangers of overpressure in pressured systems.

The BS&B Safety Head is a pressure relief device that is designed to become an integral part of any pressured system containing air, gas or liquid—either bland or corrosive.

The rupture disc of the BS&B Safety Head is custom fabricated to the specific requirements of the system of which it is a part. It provides a full pipe-sized vent for *instantaneous* relief before the pressure exceeds the safety limits of the system.

The BS& B Safety Head is especially suited to use in oil and gas producing fields, pipe lines, refineries, chemical plants, power plants and the refrigeration industry. It may be used as either a primary or secondary relief device, and either upstream or downstream from a relief valve, as varying conditions may require.

If you aren't already using BS&B Safety Heads in *your* plant, we'd suggest you get in touch with your nearest BS&B representative without delay. Or write for complete BS&B Safety Head Catalog. There's no obligation.

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THE "CIRCUIT-BREAKER" OF *Any Pressured System*

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Safety Head Division, Dept. 2-F2
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SAFETY BS&B HEADS OVER 60 YEARS

As Management Sees It . . .

Fringe Benefits Can Break You!

Continued from Page 99

ment was an advisor to the American employer delegates to the Petroleum Industry Committee Conference at The Hague in Holland. There he heard frequent reference to the American wage system as a "clean" wage system. By that was meant the employe gets his complete earnings in money, whereas in many parts of the world wages are paid out in the form of money and social services.

These social services are particularly applicable in underdeveloped countries. For example, an oil company may locate a new oil field in the jungle. To move workmen in, the companies must provide housing, cookhouses, hospitals, medical care, etc., because none are available. As the field develops, the families move in and also have to be provided for. The need for streets, sanitation, recreational facilities, even schools and churches, police protection and transportation facilities has to be met by the employers. Company stores have to be provided.

But, once these services are provided, it becomes almost impossible to get rid of any of them. The governments are slow about moving in to assume the usual municipal functions. No medical practitioner can move in because medical treatment is free. The small enterpriser cannot compete with the low prices of the company stores which are at company cost. And then follows the demand for more and more services, always at company expense.

For example, he listened to demands for "snack bars," an ambulatory dispenser of soft drinks, cookies and similar refreshments, one to every 50 workmen on the job; medical care for all relatives resident with the family; and further reduction in store prices by having the company not only assume the investment costs but the entire operating costs as well. There was also mentioned the desirability of double time pay while on vacation. Meantime, there are the usual insistent demands for higher wages. Wages admittedly are not comparable with this country's, but neither is the production of the workman.

This trend has become of increasing concern to employers in foreign countries because continued extension of it can drive them out of business.

Are the employers in this country possibly experiencing the first of a set of demands for so-called social services in addition to the present "clean wages" already the envy of the world? Medical and hospital protection is already available to employes' families at favorable rates. Is not having the employer pay the family premium merely a matter of getting something cheaper? If medical and hospital services can be forced upon the employer, why not other things? The reasoning is the same. Our company's labor relations manager knows of no union that has yet advanced the argument that family medical service is the employer's responsibil-

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SOLVENT!
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Tennessee's highest quality Liquid Sulphur Dioxide can be effectively and economically applied to your operation. We would welcome the opportunity of discussing this with you.
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CONTAINERS: Cylinders, Ton Drums, Tank Trucks and Tank Cars.

ity. The main argument is that someone else has already done so; if he can afford it, why can't you?

There are other problems associated with these social services. It plants the employer right in the middle of the employe's intimate family life and becomes a source of new and complicated personal problems. This has already given rise to a general complaint which he also heard expounded very forcefully at The Hague. The union representative arose to say, "Look here, Mr. Employer, you are making slaves of your workers. Everything around them but the air they breathe belongs to you. You own everything. The employe has no private life. Turn all these facilities over to the union and let us run them. You pay the costs, of course."

The present burden of fringe benefits, particularly in the petroleum industry, is so large that very serious thought and analysis should be given before there is any appreciable increase in present fringe benefit costs. We should carefully consider these two questions: (1) how much in the way of benefit costs can be paid safely out of productive income; and (2) should the employer assume any medical and hospital cost for an employe's family. Is this an employer responsibility or does it belong to a man who has a family?

What Can We Do About Benefits? —Tell management and employes about these benefits and how much they are costing. They're reasonable people, interested, and want to know. It certainly seems worth while to try to explain costs before the costs get out of hand and *before* pressures build up for another expensive fringe benefit.

My company has been telling its people about costs of employe benefits for many years. Examples:

- An employe handbook published in 1951, which reported the average annual cost of employe benefits as over $750 per year.
- An employe opinion poll was made in 1951-1952. In that we again pointed up the cost of employe benefits.
- This year we mailed to employes at their homes a statement about their employe benefits. We talked only indirectly about costs. An attempt was made to advise the employe and his family of the benefits he was receiving.
- At retirement, a statement to the retiring employe of what his annuity would cost if purchased on the outside. This he can check with his own insurance broker.
- An annual review by top management of employe benefit costs.

##

ENGINEERS— How to Register

Continued from Page 179

approved years of experience in engineering may qualify for the preliminary or E.I.T. written examination. Qualification for the full Professional License (P.E.) would automatically follow after an additional approved four years of internship in the engineering office or the job site.

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Utah: Frank E. Lees, Director, 324 State Capitol Building, Salt Lake City.

Vermont: Walter D. Emerson, Secretary, c/o Norwich University, Northfield.

Virginia: Turner N. Burton, Executive Secretary, 305 Finance Bldg., P. O. Box 1-X, Richmond.

Washington: Edw. C. Dohm, Secretary, Dept. of Licenses, Professional Division, Transportation Bldg., Olympia.

West Virginia: Robert Williamson, Jr., Secretary, 301 Morrison Building, Charleston.

Wisconsin: W. A. Piper, Secretary, 1100 State Office Bldg., Madison 2.

Wyoming: Mrs. Wilma H. Lang, Asst. Secretary, 201 State Capitol Bldg., Cheyenne.

# #

As Management Sees It . . .

KNOW YOUR FABRICATOR BEFORE YOU BUY

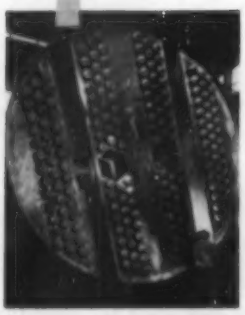
One of a series . . . designed to acquaint you with

NOOTER ST. LOUIS

EXAMPLES
speak louder than words

A custom fabricator is known by the jobs he actually produces. Illustrated here is a Nooter job—a fractionating column recently delivered to the petroleum refining industry. The size of this job is one example of Nooter's experience:

- 13 ft. diameter, 155 ft. long, weighing 235 tons.
- All-carbon steel, stress relieved in the Nooter Heat Treating Furnace.
- Six flatcars needed to ship to destination.
- Over 10,000 bubble caps, installed in 55 trays. Assembled trays had to satisfy a tray level tolerance of ±⅛".
- Final field assembly, engineered by Nooter Field Construction Dept.
- Completed and delivered on time within 4 months of order.



One of the 55 bubble trays containing over 10,000 bubble caps.

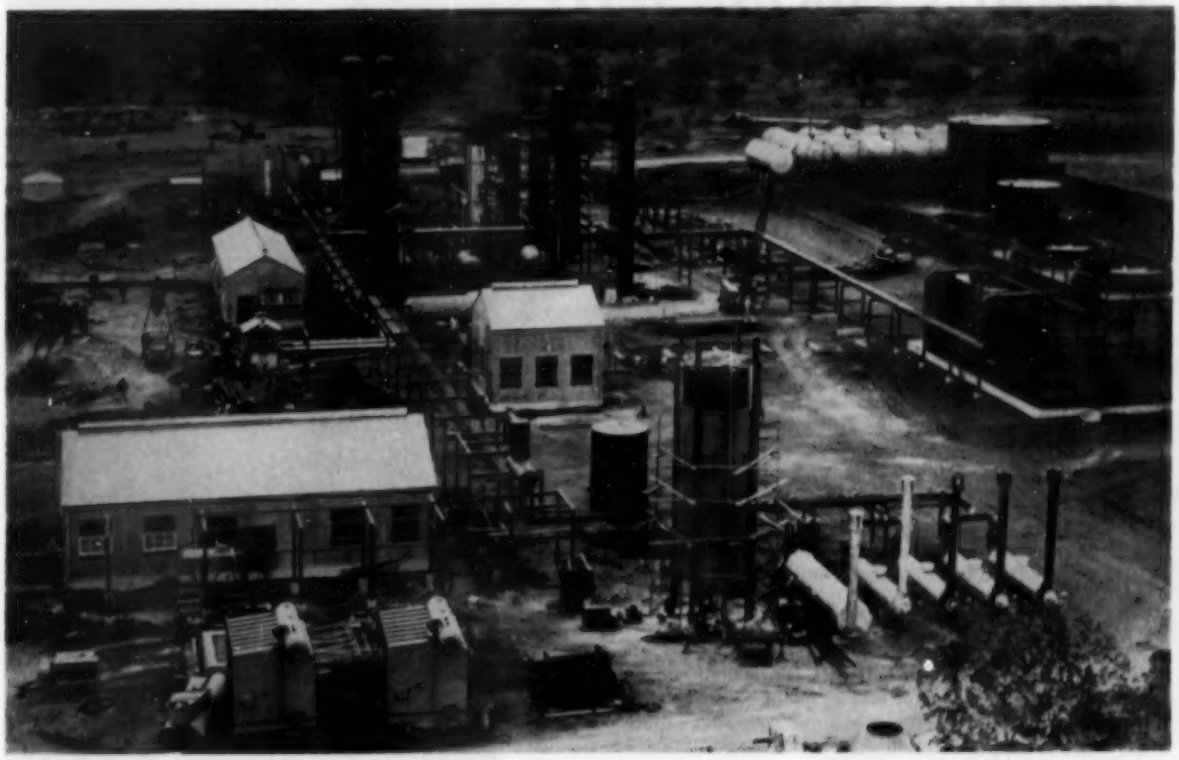
Your custom fabrication of tanks and processing vessels in steel or any alloy, from 12 gauge to 4" plate, will be handled with the same skill, backed by 58 years of experience, with a dependable delivery date and at competitive prices.

NOOTER CORPORATION

Since 1896

1404 South Second St. • Saint Louis 4, Missouri

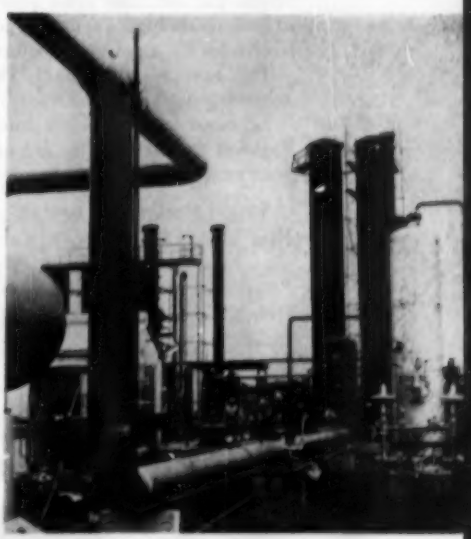
Steel and Alloy Plate Fabricators and Erectors . . . "Boilermakers"



The new Cabeza Creek gasoline and dehydration plant will process 100 Mmcf of natural gas a day from 26 fields in three Texas counties.

United Gas Starts Producing At New Texas Gasoline Plant

About 70,000 gallons of liquid products a day will be recovered by the Cabeza Creek plant at Runge.



Portion of the inlet separator is shown at extreme left, with a line leading to the two absorber towers.

THE SECOND LARGEST installation operated by United Gas Pipe Line Company for the recovery of liquid hydrocarbons from natural gas began operation last month near Runge, Texas.

Under construction since last August, the Cabeza Creek Gasoline and Dehydration plant is located on a 90-acre site eight miles southeast of Runge. It will be the second installation of its type operated by the company in Karnes County. With a capacity to handle 100 Mmcf of natural gas a day, it is exceeded in size by only one of United's seven other gasoline plants in Texas and Louisiana. The company's largest plant is at Carthage, Texas.

When in full operation, the plant

LUMMUS COKING UNITS
give top performance for
Pan-Am Southern

Lummus has built two delayed coking units for Pan-Am Southern Corporation in the past few years, one at El Dorado, Arkansas, and the other at Destrehan, Lousiana... and Pan-Am Southern is well satisfied with them.

The El Dorado unit, despite a 42 day steel strike during the construction period, was completed ahead of the specified date, and for less than the guaranteed maximum cost. It was designed to charge 9,300 B/D of reduced crudes, but since coming on-stream, the daily rate has averaged 10% above the designed capacity. The unit went on-stream immediately and operated 181 out of the first 199 days after completion (a 91% service factor). In the first half of 1953, it achieved and has since averaged a 97% service factor (224 day run, 6 day down-time). On-stream maintenance and repair costs are correspondingly low.

Gas oil from the coker (53% yield of reduced crude charge) is used for catalytic cracking charge stock where its low Conradson carbon allows it to be processed without penalty. Yield structure compares favorably with that obtained from catalytic cracking of virgin gas oil. The coke produced in the process is of sufficiently high quality for use in the manufacture of electrodes for aluminum production.

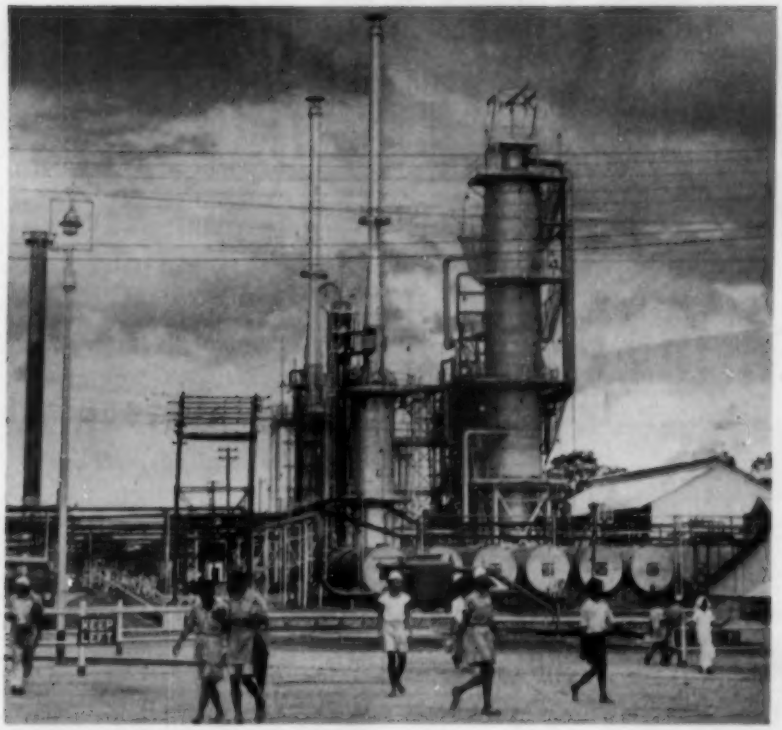
The new (and similar) Destrehan installation is achieving equally satisfactory records.

Lummus engineers have done an outstanding job for Pan-Am Southern. Why not consult with Lummus on *your* next coking project?

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, New York. *Engineering and Sales Offices:* New York, Houston, Montreal, London, Paris. *Sales Offices:* Chicago, Caracas. *Heat Exchanger Plant:* Honesdale, Pa. *Fabricated Piping Plant:* East Chicago, Indiana.

LUMMUS

DESIGNING ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM AND CHEMICAL INDUSTRIES



Assam Oil Adds Lube Oil Unit—

Latest addition to Assam Oil Company's expanding refinery at Digboi, in the northeastern tip of Assam State, Ind., is this new lube oil unit. Designed by Foster Wheeler Corporation and erected by AOC engineers, it is a two-stage unit with a charging capacity of 60,000 gallons of oil daily.

will recover approximately 70,000 gallons of liquid products daily.

In addition to the liquid recovery and dehydration facilities, the installation will have tank storage capacity for approximately 550,000 gallons of gasoline and liquefied petroleum gases.

Plant foreman of the new facility is Ambrose Meeks, a veteran of 25 years with United. Prior to his transfer to Karnes County, he was foreman of the company's gasoline plant at Koran, La. C. B. Witcher, formerly of United's Karnes City gasoline plant, will be the first operator. The four operators, all of whom have worked at other company gasoline plants in Texas, will be Sam McCoy, G. O. Johnson, J. A. Smith and B. L. Hunt.

Fish Engineering Corporation had the contract for design and construction of the plant facilities.

Anhydrous Ammonia Plant Will Be Built in Maine

Construction of New England's first anhydrous ammonia plant has been planned by Northern Chemical Industries, of Searsport, Maine. The plant, representing N.C.I.'s entry into the anhydrous ammonia industry, will be the first facility using exclusively the Texaco-Hydrocarbon Research process for producing ammonia synthesis gas from Bunker "C" fuel oil by partial oxidation with oxygen.

The plant will be erected at Searsport.

Included in the over-all project are a 125-ton-per-day anhydrous ammonia plant, a 60-ton-per-day nitric acid plant, a complete nitrogen solutions plant and auxiliary units for producing steam, electric power and other utilities. The investment will total about $9 million.

The nitric acid plant will employ the ammonia oxidation process at approximately 100 pounds pressure and will be designed to produce 60 tons of nitric acid (100 percent basis) at a concentration of 55 to 60 percent. The plant will be built for possible expansion to 120 tons per day.

Who's Building. . .

Three Companies Receive ODM Write-Off Approvals

Humble Oil & Refining Company has been granted rapid tax amortization on construction of an 18,000-barrel-a-day platinum catalyst hydrogen reformer at its Baytown, Texas, plant.

Office of Defense Mobilization issued certificates permitting the company to write off the $3,750,000 project at the rate of 65 percent on $3,393,500 and 50 percent at $366,500.

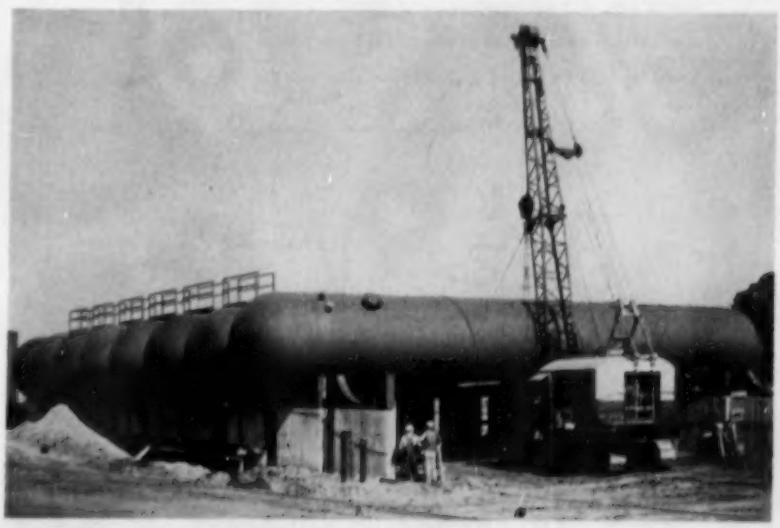
The company also was allowed amortization on construction of a 30,875-barrel-a-day catalytic desulfurization feed treater to be built at the Baytown refinery. Write off will be permitted on $770,000 at a rate of 65 percent and $28,500 at 50 percent.

Pure Oil Company was approved for construction of a gas-gathering system and natural gasoline plant in Morgan County, Colo. Expected to process 14 Mmcf a day, the plant will be retired at 65 percent on $2,395,000. The company will be allowed 40 percent on $682,750 for the gathering system.

Also receiving a grant is Esso Standard Oil Company, which was allowed a 45 percent amortization on $2,120,000 to be spent for installation of facilities to convert an existing batch gasoline blending system to a semi-automatic operation at its Bayway refinery near Linden, N. J.

Ohio Oil Will Build Denver Research Lab

Construction of a new petroleum research laboratory in the Denver area is planned by The Ohio Oil Company. J. C. Donnell II, president of Ohio Oil, together with several officials from the company's general office, were in Denver recently looking over likely locations for the labo-



Touchy Job, This One—

A delicate job indeed was the unloading and placing of these king-size tanks at McMurrey Refining Company, Tyler, Texas, since the tank shells are only 0.250 inches thick. Under the direction of the Chemical Plants division of Blaw-Knox Company, Pittsburgh, the 70-foot-long isopentane tanks were unloaded from trucks and placed in saddles—in pairs—in two hours and 15 minutes. Diameter of the tanks is 10 feet 10 inches.

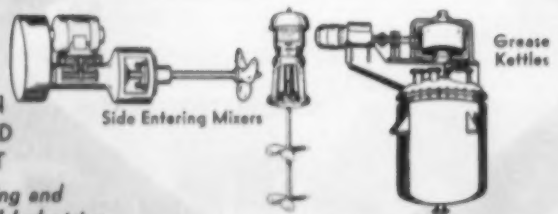
Patterson

Top Entering MIXERS

—do a low cost, top quality job over a wide range of your agitation requirements

Patterson Standardized Top Entering Mixers are top value for your agitating-mixing dollars —in four different models, for use with propellers, turbines, gas absorber units or other mixing elements. These units are sturdy, long-lived, low in maintenance, and handle liquids up to 2000 centipoises in viscosity. Sizes range from ½ to 5 H.P. Let us quote on your needs.

Richard L. Cameron
President



PATTERSON SPECIALIZED EQUIPMENT
for the Refining and Petrochemical Industries

The Patterson Foundry and Machine Company
East Liverpool, Ohio, U. S. A.
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The Patterson Foundry and Machine Company, (Canada) Limited
Toronto, Canada
MONTREAL

Who's Building . . .

ratory which would employ some 100 personnel at the outset.

W. H. Barlow, manager of the company's Research department, is now in Denver meeting with Arapahoe County Commissioners towards getting approval for the building of new laboratory on an 80-acre tract on South Broadway, 11 miles from downtown Denver.

The company plans to exercise its option on approval to build by the commissioners and then to break ground as soon as possible in the spring. Completion of the laboratory is scheduled for the first part of 1956.

Construction

Planned and Projected:

Black Thunder Oil Company, of Rapid City, S. D., has awarded Russell Engineering Company of Houston a contract to construct a $400,000 gasoline plant in Wyoming's Clareton oil field. Plans call for the processing of 5 Mmcf of natural gas a day.

Century Refining Company, Inc., a newly formed Wichita, Kan., company, plans to reopen the Shallow Water, Kan., refinery closed last September by Shallow Water Refining Company. Before shutting down, the Shallow Water refinery processed 2000 to 3000 barrels a day.

Simpson Coal & Chemical Corporation plans to build a major petrochemical plant at Natchez, Miss. The basic plant will convert natural gas fractions to acetylene, producing about 30,000 tons a year. By-product hydrogen from the acetylene process will be used in the production of about 60,000 tons of synthetic anhydrous ammonia a year, or about 165 tons a day.

Cities Service Oil Company and **Forest Oil Corporation** will begin building a large natural gasoline plant in western Midland County, Texas, next month. Capable of processing 50 Mmcf of gas daily, the installation will cost almost $7 million.

Gulf Oil Corporation has let contracts on a building and redevelopment program for increasing the capacity for gasoline production at its Port Arthur, Texas, refinery.

Major units to be added during the program are a 68,000-barrel-a-day Fluid catalytic cracking unit, and a 1,000,000-barrel-a-day crude topping and vacuum unit. In addition, the program will include the erection of a 300,000 pound-per-hour steam boiler, a water cooling tower, new gas treating unit and additional amine treating units for use in sulfur production.

A number of older refining installations, primarily combination units for crude topping and thermal cracking, will be shut down as part of the program. This will result in the elimination of thermal cracking at the refinery.

The redevelopment and structural work is expected to start early this year and to be completed within a year. General contracts have been let to The M. W. Kellogg Company for the Fluid catalytic cracking unit and to Arthur G. McKee Company for the crude topping and vacuum unit.

For more data on advertised products, use Readers' Service Cards, last page.

PACKAGED COMPRESSOR *SPEEDS* PENETRATION RATES ON TEST WELLS

OIL INDUSTRY TECHNOLOGISTS, investigating methods of reducing present-day drilling costs, recently started a series of tests using aerated mud. Of major importance to this program was the selection of a compressor. The unit had to deliver, automatically, full rated capacity over a wide range of pressures — to operate virtually unattended, leaving the crew free for regular duties. When moving it was essential that only oil field equipment be used and no special foundation required at the drilling site.

A Beaird-Ingersoll-Rand 4-Cycle Packaged Compressor Plant, 220 horsepower 8 JVG, was purchased by Phillips Petroleum Company for this task. Beaird engineers installed automatic controls that permit it to slow down or pick up speed over a range of 50% to 100% according to discharge conditions. A stop valve on the rig floor is all that is required to shut off air instantly for a connection or a trip. Other automatic controls safely handle this sudden change in operation — slowing the engine and unloading the compressor cylinders.

Mounted on its own heavy steel skid base, the compressor is set in a shallow pit near the rig and ballasted with sand or caliche. It moves as a single over-the-road package between drilling sites. On the new location only connections to fuel and mud lines are required to place it into operation.

Let us show you how a Beaird-Ingersoll-Rand packaged compressor plant can be designed to meet your requirements. Sizes 110 h.p. to 660 h.p.

▲ Beaird-Ingersoll-Rand 220 h.p. 8 JVG four-cycle gas engine driven compressor equipped with Young radiator and all necessary equipment and controls on Phillips Petroleum Company's drilling rig.

THE J. B. BEAIRD COMPANY, INC.
Shreveport, Louisiana

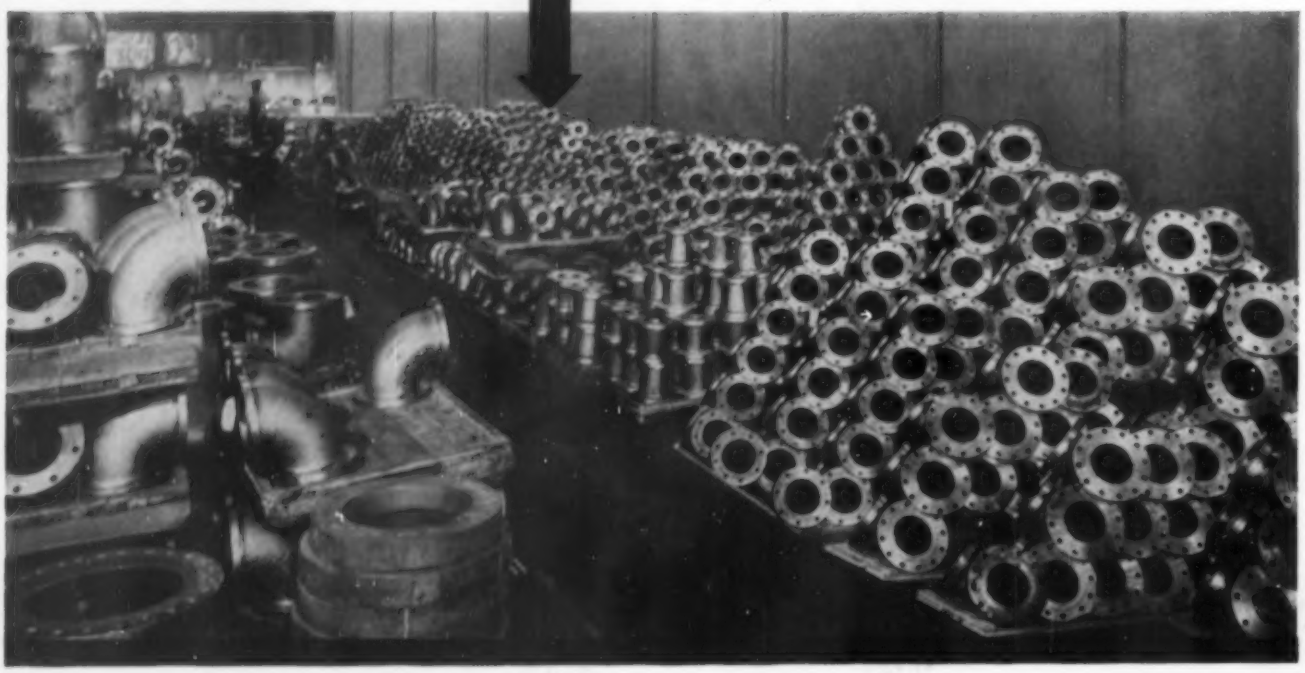
BEAIRD

MACHINING • MANUFACTURING • STEEL WAREHOUSE

PACKAGED COMPRESSOR PLANTS | CAST STEEL FITTINGS | PRESSURE BULK STORAGE | ANHYDROUS AMMONIA EQUIPMENT | LP-GAS SYSTEMS

BEAIRD *Cast Steel Fittings* fittings that fit

Fittings off the shelf



That's right . . . Beaird has a complete stock of standard fittings available to meet demand!

Now, you can avoid costly delays and downtime by requesting DIRECT SHIPMENT thru your supply house or by calling us direct! Fast delivery on special fittings too . . . from our large assortment of patterns.

Speed up ordering by using the handy selection charts and figure numbers in Beaird's new Catalog No. 153 . . . write for your copy today!

Beaird also has complete facilities for manufacturing special items to your specifications.

Gasket Faces Machined with Fine Phonographic Finish

Why Beaird fittings are known for their true fit and high quality the world over

Flanges Fully Backfaced

Bolt Hole Circles and Flange-Circumferences Concentric with Bore

THE J. B. BEAIRD COMPANY, INC.

Shreveport, Louisiana

BEAIRD

MACHINING MANUFACTURING STEEL WAREHOUSE

PACKAGED COMPRESSOR PLANTS

CAST STEEL FITTINGS

PRESSURE BULK STORAGE

ANHYDROUS AMMONIA EQUIPMENT

LP-GAS SYSTEMS

Humble Oil and Refining Company will build another new reforming unit at its Baytown, Texas, refinery. To cost approximately $3,750,000, it will be Humble's Hydroformer No. 2. Announcement of the plans came on the heels of the Office of Defense Mobilization's grant to Humble of a certificate of rapid tax amortization of 65 percent on $3,393,500 of the cost, and 56 percent write-off on the remainder.

Northeast Texas Chemical Company has awarded Tear Engineers of Dallas, Texas, a contract for the engineering design of a chemical and fertilizer plant in East Texas. Construction of the plant will be handled by Henry C. Beck Company, also of Dallas. Products and capacities have not been announced.

The Pure Oil Company will build a catalytic reforming unit at its Smith Bluffs, Texas, refinery.

Pacific Oil and Refining Company plans to start construction of its 10,000-barrel-a-day refinery near Tacoma, Wash., before June. Dredging operations in the Tacoma mud flats have already been started. According to present plans, the plant will operate on Canadian crude oil brought in by tankers from the Vancouver, B. C., terminal of Trans Mountain Oil Pipe Line.

The Atlantic Refining Company has licensed four more refineries to use the Catforming process developed by Atlantic for the production of high octane gasoline. British American Oil Company, Ltd., will install a 13,000-barrel-a-day Catformer at Montreal and a 2000-barrel-a-day Catformer at Calgary. Completion of the Montreal unit is scheduled for late 1955, while the Calgary unit is expected to start up in February, 1955. Husky Oil and Refining Company, Ltd., will install two 1000-barrel-a-day Catformers, one at Moose Jaw and one at Fort William. These units are scheduled to start up in July, 1955.

Ethyl Corporation plans to build a plant at Sarnia, Ont., Canada, to manufacture antiknock compounds. The plant will be owned and operated by Ethyl Corporation of Canada, Ltd., a subsidiary of Ethyl Corporation. The new plant is expected to be completed and in production by the early part of 1956.

Shell Oil Company of Canada, Ltd., will increase the capacity of its Montreal East refinery from 44,000 to 55,000 barrels a day. A vacuum flasher and the addition of 3500 barrels a day to the capacity of the 16,500-barrel-a-day fluid cat cracker are included in the first phase in the expansion, which will cost an estimated $4 million. Arthur G. McKee Company of Canada, Ltd., has been awarded the contract to build the vacuum flasher; Shell engineers will handle the work on the cat cracker. No dates for the expansion have been announced.

Supertest Petroleum Corporation plans construction of a multimillion dollar refinery in Southern Ontario.

American Companies are rumored to be studying possibilities of establishing petrochemical production in Venezuela to utilize vast quantities of natural gas from the country's oil wells.

At present, it is reported, billions of cubic feet of gas are being dissipated in Venezuela each year, aside from the amounts needed for fuel or for re-injection in low-pressure wells, because no other uses for it have been developed.

President Perez Jimenez, in a message to the Venezuelan national congress, has deplored the natural gas waste and pointed out that potentially 3000 items could be produced in his country from petroleum or natural gas.

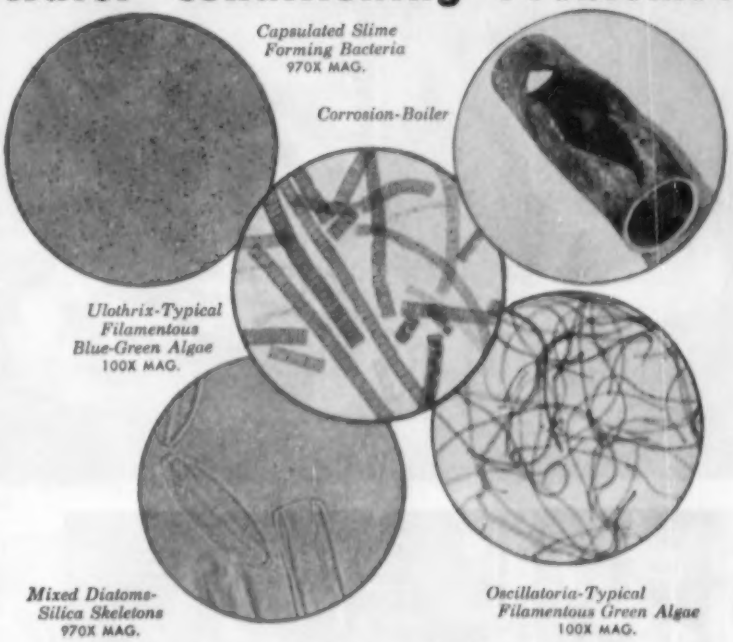
If a new petrochemical industry is started in Venezuela, executives of American oil companies say, it will probably produce in the beginning ammonia and fertilizers with a hydrogen base. Later, they asserted, the range of products may be broadened to include chlorine, caustic soda and insecticides, followed still later by ethylene, propylene, glycol, benzol, plastics, dyes, synthetic gums, detergents, solvents and others.

Who's Building . . .

Standard-Vacuum Oil Company plans an extensive modernization program at its Sungei Gerong refinery in Palembang in South Sumatra as part of its capital investment program in Indonesia. Its investments in that area are expected to reach between $70 and $80 million over the next four years.

Government of India has received a report from its Synthetic Oil committee, recommending construction of a 300,000-ton-a-year synthetic oil plant. The report sugggested that synthetic fuel production

What Causes Your Water Conditioning Problems?



Be Sure You Get the WRIGHT Answer

IN the photographs above you probably won't recognize the culprit in your water that may be giving you trouble. No one would expect you to. After all, water conditioning problems are individual, requiring individual analysis, individual solution.

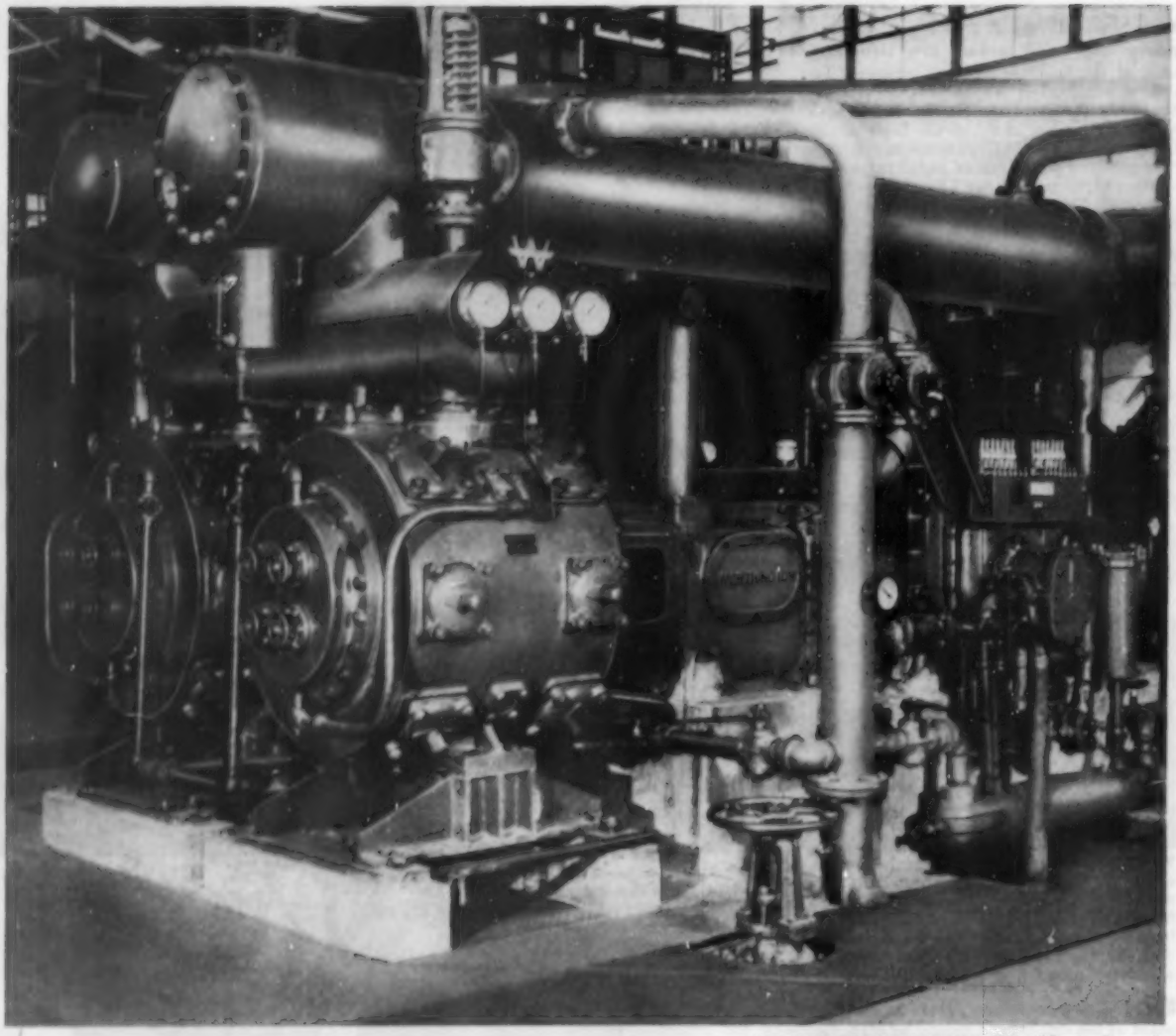
This is the Wright Service: A laboratory analysis is made—a written proposal gives recommendations for solution—then frequent checks are made to assure continued efficient performance.

Let *us* recognize your water conditioning problem and solve it for you. Write or call for a thorough survey by a Wright Field Engineer.

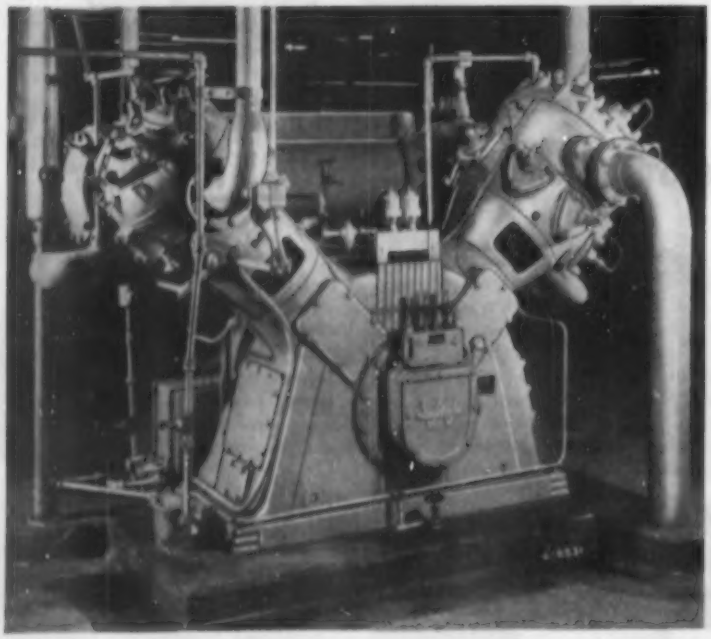
Wright CHEMICALS

WRIGHT CHEMICAL CORPORATION
GENERAL OFFICES AND LABORATORY
615 WEST LAKE ST., CHICAGO 6, ILL.
Offices in Principal Cities
- Softeners, Filters and other External Treating Equipment
- Nelson Chemical Proportioning Pumps

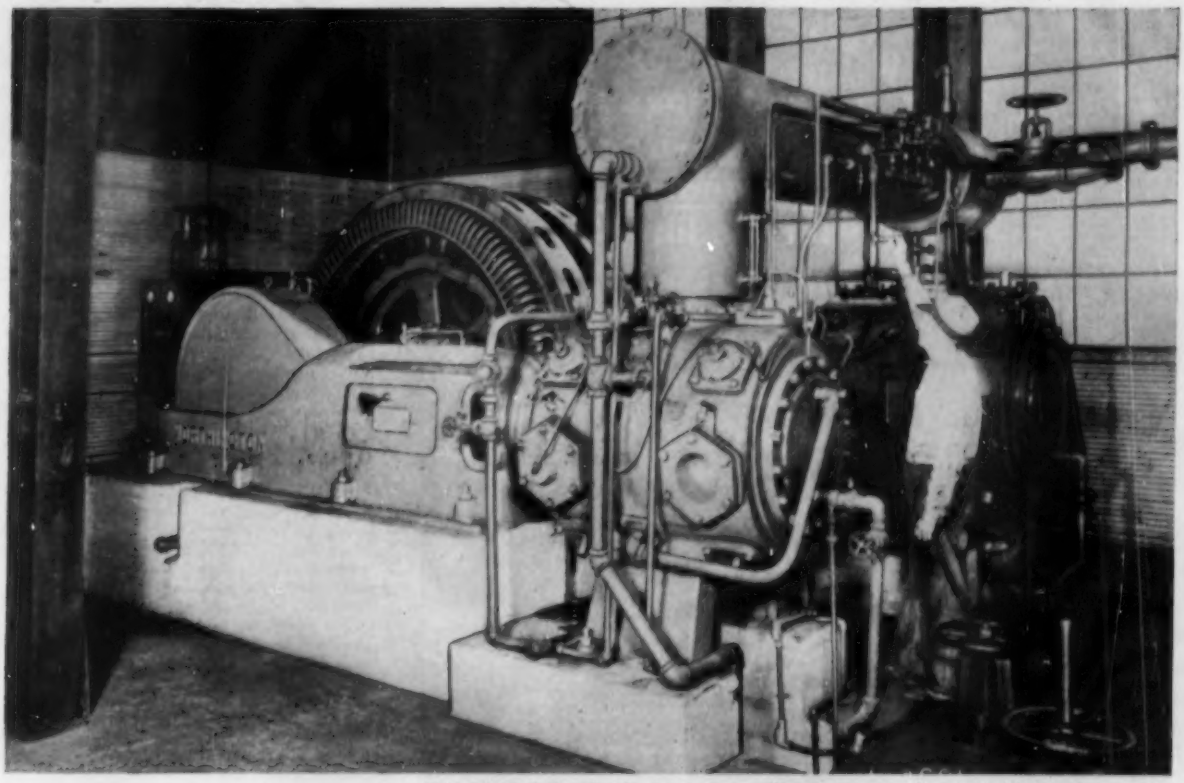
For more data on advertised products, use Readers' Service Cards, last page.



LOOKING FOR VERSATILITY? Worthington's modern, balanced-opposed type compressor really fills the bill. Units like the one shown above (at work in a large chemical plant) are ideal for either multiple- or single-service applications. They're also widely used for high-pressure, multi-stage work as well as low-pressure jobs. Like the rest of the large Worthington compressor family, the versatile balanced-opposed unit is equipped with the exclusive Feather* Valve, the lightest, tightest, most efficient valve made. Sizes range from 400 to 5000 hp. *Reg. U.S. Pat. Off.



GREAT SAVINGS IN INSTALLATION COSTS. The "packaged" Worthington Y-type compressor is delivered completely assembled, with no lining-up to do in the field. It needs only a small, simple foundation — and can be placed in operation within hours after it has been set on the foundation. Sizes range from 75 hp to 350 hp.



FOR HEAVY-DUTY, day-in-day-out operation at top capacity, the Worthington DC compressor is the right choice. These dependable compressors have been making friends for us for over fifty years. Sizes range from 250 to 2500 hp.

Get the right compressor for the job

Because Worthington builds every type and size of compressor and compressor drive, you're assured of getting unbiased compressor recommendations

DEPENDABILITY. That's what you get with the Worthington HB compressor — smaller version of the DC. For an economical, continuous supply of air in smaller quantities, the HB's are unexcelled. They can be used as single-stage units or hooked up in tandem for two-stage work. Sizes range from 10 to 125 hp. K.4.8

We'd like to hear about your compressor needs. Write to Worthington Corporation, Water-Cooled Compressor Division, Section K.4.8, Buffalo, New York.

WORTHINGTON

Only Worthington Compressors give you Feather Valve Performance

Y-Types • Balanced Angle • Balanced-Opposed • Direct-Connected • Gas Engine

Expansion joints have to be trouble-free and maintenance-free in service like this...
"HIGH WATER MARK"
That's why
FLEXON EXPANSION JOINTS
were specified here

In the tunnel installation pictured above working conditions are quite a bit short of ideal. As the "high water mark" shows, the tunnel is often flooded. It is also quite inaccessible . . . not a very desirable place to have to do maintenance work on expansion joints. To be sure of trouble-free service *without any maintenance* Flexon Expansion Joints were installed here.

Flexon Expansion Joints are the modern way to control piping expansion and contraction. In addition to being maintenance-free, they are compact, in-line units, as easy to install as a fitting. Flexon Expansion Joints are scientifically designed and fabricated to give maximum life and dependability, backed by over 50 years experience in the manufacture of flexible metal components.

Complete selection and application data are given in the Expansion Joint Design Guide. Be sure to see this bulletin before you specify expansion joints for your plant. Write for your copy, today.

Flexonics *Corporation* EXPANSION JOINT DIVISION

1336 S. THIRD AVENUE • MAYWOOD, ILLINOIS

FORMERLY CHICAGO METAL HOSE CORPORATION

Flexon identifies products of Flexonics Corporation that have served industry for over 50 years.

Manufacturers of flexible metal hose and conduit, expansion joints, metallic bellows and assemblies of these components. In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario

Who's Building...

should include 85,000 tons of aviation gasoline, with the remaining 215,000 tons made up of automobile gasoline, diesel oil and lubricants. A project report will be prepared before the government discusses the amout of capital to be invested in the new plant.

Finland is expected to start construction of its proposed new refinery early next summer. The unit, first for Finland, is to be built near Turku by the state-owned Neste Corporation. Bids for construction were being studied last month, with one of the earliest being a proposal by Moscow that Soviet engineers build the refinery, already planned to process Soviet crude. The installation is to have a capacity of 14,000 barrels a day. Decision on all bids should be reached by March, a Finnish industry official said.

The Dow Chemical Company plans a wholly-owned subsidiary in the Netherlands, to be called Nederlandsche Dow Maatschappij N.V., and construction of a manufacturing plant and tank storage, warehouse and docking facilities at Rotterdam.

No estimates of total cost or scheduled completion date have been given. The new subsidiary will process polystyrene plastics, magnesium alloys, glycols and other chemicals.

Dow Chemical will ship basic raw materials from its U. S. plants to Rotterdam. Its subsidiary will also buy Dutch and other European raw materials.

Refineria de Petroleos de Escombreras S.A. has been authorized by the Spanish Ministry of Interior to expand the capacity of the Escombreras refinery near Cartagena to about 70,000 barrels a day from its present 36,000 barrels a day.

Greek government has selected Hydrokarbon Mineralol GMBH, a West German firm, to build its projected 30,000-barrel-a-day refinery. Bids had been narrowed down to a choice between Hydrokarbon and Ude, another West German firm, when the contract was awarded.

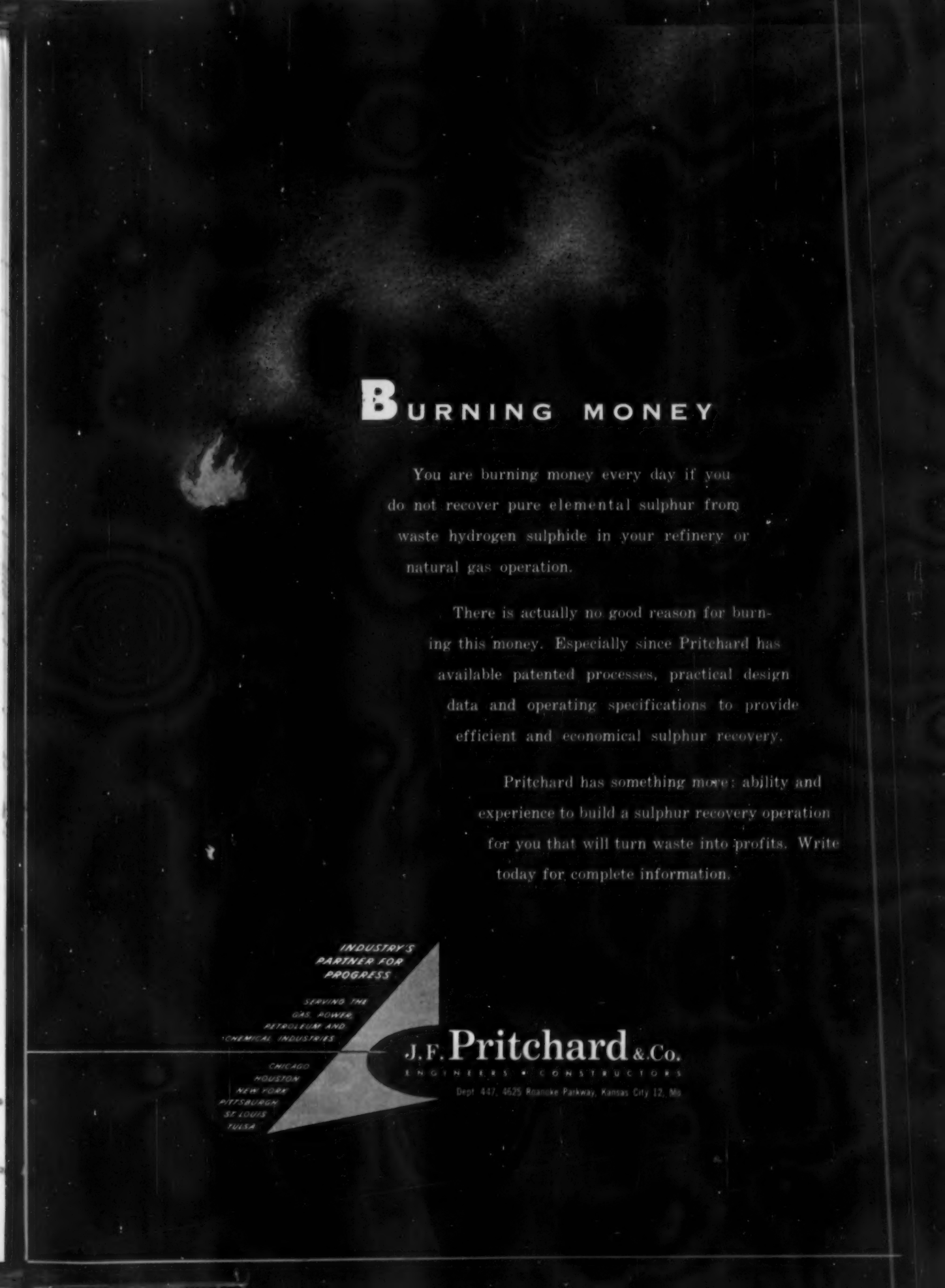
Bids by Socony-Vacuum Oil Company and the Skouras-Pappas group are said to have been rejected because they covered not only construction of the refinery but its "exploitation."

Bidders had been invited to submit proposals for operating the refinery. No decision has been announced as to the operator, however.

Tide Water Associated Oil Company reportedly will award the contract for the construction of its proposed 130,000-barrrel-a-day refinery to be built on the East Coast very shortly. Delaware City, Del., is rumored as the location, and C. F. Braun Company, Alhambra, Calif., is said to be tabbed for overseeing the construction. The M. W. Kellogg Company will probably design a large Orthoflow catalytic cracking unit for the project, and Houdry Process Corporation a Houdriformer.

Frontier Refining Company plans a $1.5 million expansion of its 14,500-barrel-a-day refinery at Cheyenne, Wyo. Construction, scheduled to begin this spring will increase the plant's crude capacity to between 17,000 and 17,500 barrels a day.

Included in the expansion program will be a new 2000-barrel-a-day platformer, a 3000-barrel-a-day unifiner and a 2500-barrel-a-day atmospheric distillation unit, along with a new steam plant and addi-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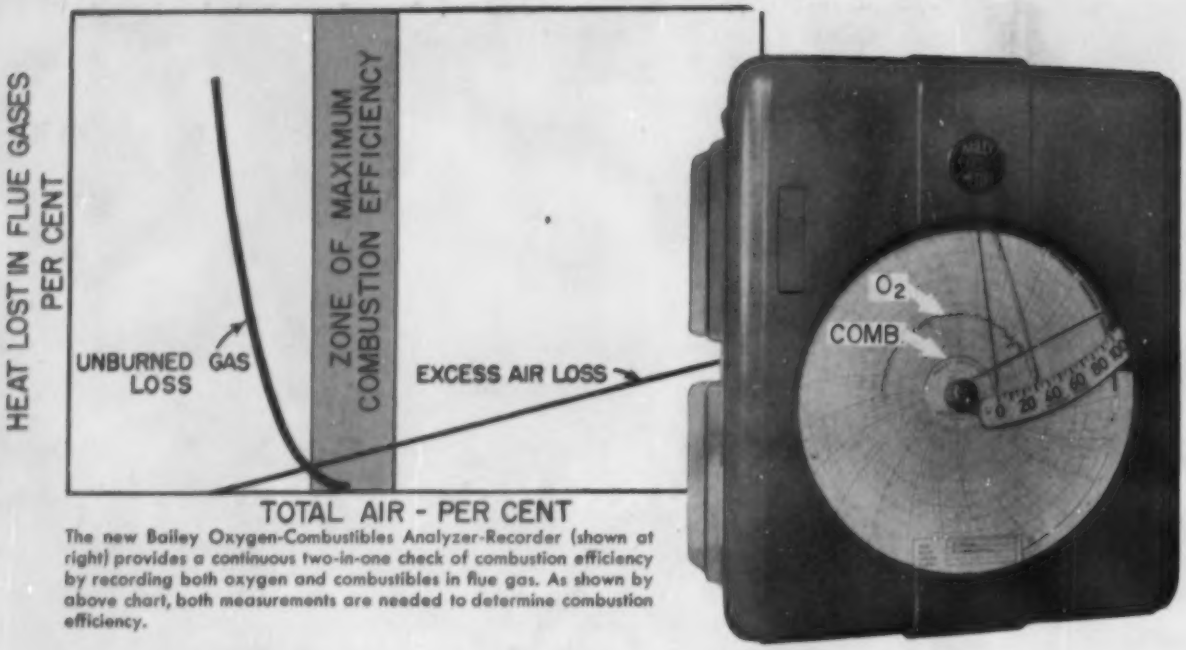

The new Bailey Oxygen-Combustibles Analyzer-Recorder (shown at right) provides a continuous two-in-one check of combustion efficiency by recording both oxygen and combustibles in flue gas. As shown by above chart, both measurements are needed to determine combustion efficiency.

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The new Bailey Oxygen-Combustibles Analyzer-Recorder gives you a continuing double check on combustion economy. It's fast response measures and records:

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2. The mixing efficiency of your fuel-burning equipment—by indicating the amount of combustibles in your flue gas, resulting from incomplete mixing of fuel and air.

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Now, for the first time, you can check *both* with a *single* fast acting instrument, using the new Bailey Oxygen-Combustibles Analyzer-Recorder for industrial furnaces, kilns, heaters and boilers.

Fuel economy improves as excess air is reduced —until unburned fuel begins to show up in the flue gas. When this happens, combustion efficiency drops off sharply if there are further decreases in the air-fuel ratio. That's why combustion gases must be analyzed for *both* oxygen and combustibles to get a true indication of efficiency—and that is why Bailey coordinates both measurements on the same chart, to show when excess air may be reduced safely without danger of greater losses from unburned gases.

The Bailey Oxygen-Combustibles Analyzer is an approved combustion safeguard.

Ask your local Bailey engineer for suggestions on application. Equipment details in Product Specifications E65-1 and E12-5. P31-1

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Who's Building. . .

tional storage facilities for 100,000 barrels. Construction is to be completed this summer.

Petrobras, Brazilian government oil monopoly, has made plans calling for the immediate construction of a 25,000-barrel-a-day refinery in Belem or Racife, according to its president, Col. Arthur Levi. Also contemplated is an expansion of the Mataripe refinery to 15,000 barrels a day, and an expansion of the recently completed Cubatao refinery to 70,000 barrels a day.

Calvo Sotelo Company plans to build a second refinery on the Spanish mainland. The new plant is to be built at Puertollano, Ciudad Real Province, where Calvo Sotelo has recently completed the construction of a shale oil (crude) plant. Calvo Sotelo is owned by the Spanish government industrial organization, Instituto Nacional de Industria.

The shale oil produced at Puertollano will be refined in the new refinery instead of being sent to the refinery of Rafineria de Petroleos de Escombreras S.A., as is the present practice. The new plant will also process imported crude.

Indian government has approved in principle a plan to build Asia's first synthetic oil plant, one which would turn out about 6000 barrels a day, or about 10 percent of the country's requirements. Output of the plant would include about 4300 barrels a day of motor gasoline, diesel oil and lubricants and 1700 barrels a day of aviation gasoline.

Calumet Nitrogen Products Company, recently formed by Standard Oil Company of Indiana and Sinclair Refining Company, will build a 300-ton-a-day anhydrous ammonia plant at Hammond, Ind. The plant, scheduled to be completed in May, 1956, will be capable of converting part of its ammonia output to nitrogen solutions.

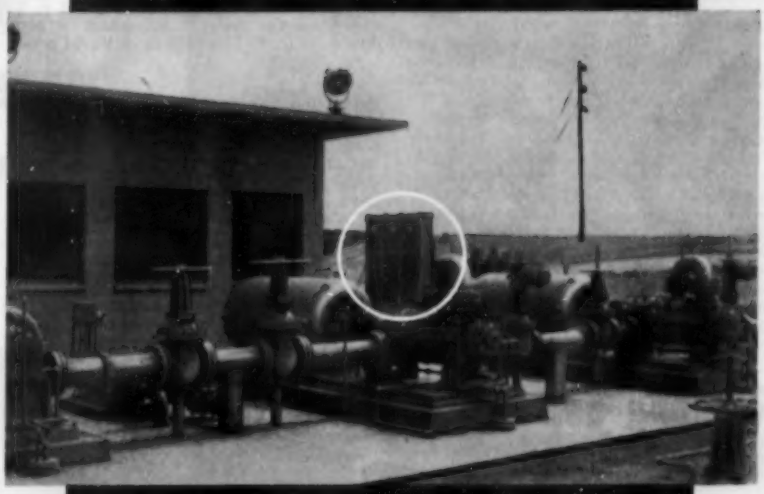
Construction Completed:

Lake Superior Refining Company has completed an extensive two-year modernization and expansion program at its Superior, Wis., plant. Included in the modernization program was a new vacuum distillation and asphalt unit for the production of a complete range of asphalt products. At the same time, the crude unit and thermal cracking unit were modified for increased operating efficiency. The entire program was designed to provide facilites for producng high grade motor fuels.

Last installation built was a 1000-barrel-a-day UOP Platforming unit. Built by Procon, Inc., the unit was completed in only 24 weeks from the time Procon received authority to begin engineering. The refinery now has a capacity to process 6000 barrels a day of crude.

Kerr-McGee Oil Industries, Inc., has started up a new UOP Fluid catalytic cracking unit and a new UOP Polymeri-

EC&M 2200-5000 VOLT



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Who's Building . . .

zation unit at its Wynnewood, Okla., refinery. The cat cracker has a design capacity of 5650 barrels a day and is processing gas oil derived from a mixture of Southern Oklahoma crudes. Startup of the new units winds up an extensive modernization and expansion program at Kerr-McGee's refinery during which the crude unit was revamped and the capacity increased from 8500 barrels a day to 15,000 barrels a day, and a new gas concentration system costing approximately $5 million was installed. The Refinery Engineering Company of Tulsa performed the construction work on these projects. Both the cat cracker and the polymerization units were designed, engineered and licensed by Universal Oil Products Company.

Continental Oil Company is now operating a new $2 million natural gasoline plant and gas gathering system south of Bush, Colo. Capacity of the plant is 10 Mmcf of gas daily, from which is produced about 70,000 gallons of liquid products.

Canadian Industries, Ltd., officially opened its newly expanded polyethylene plant at Edmonton, Atla., recently after the plant had been in operation for some time. The plant now has a capacity to produce about 16 million pounds of plastics a year.

Petroleos Mexicanos, Mexico's oil agency, expanding in all directions, last month dedicated one of its many projects, the lubricating oil and wax plant at its Salamanca refinery. Units added to the refinery in the recently completed expansion include: two-stage furfural solvent extraction; two-stage propane deasphalting unit; high-vacuum distillation unit; M.E.K.-toluene solvent dewaxing plant; vacuum rerun unit and wax treating unit. The expansion raised the refinery's capacity from 30,000 to 40,000 barrels a day.

Other projects being pushed by Pemex: a $30 million modernization of the Cuidad Madero, Tamulipas, refinery, which will result in a 100,000-barrel-a-day capacity; a $12 million expansion of the Minatitlan installation, to include toppng unit, feed preparation unit, a TCC catalytic cracking unit, and polymerization unit, to raise the refinery's capacity to 25,000 barrels a day; and a $20 million expansion of the Poza Rica facilities, including gas absorption purification, water and gas repressuring, to raise capacity to 120 Mmcf a day.

Societe Generale des Huiles de Petrole has commissioned a new UOP Platforming unit at its Lavera, France, refinery. It is the first such unit to be built in France and the third to go into operation out of a total of six being constructed for the British Petroleum Company Ltd. Group (Formerly Anglo-Iranian Oil Company, Ltd.), of which the French company is a part. The 6000-barrel-a-day unit was designed, engineered and licensed by Universal Oil Products Company.

U. S. Industrial Chemicals Company has dedicated a $7 million plant at Tuscola, Ill. The facilities will produce synthetic ammonia and fertilizer nitrogen compounds, with a production capacity of 50,000 tons of anhydrous ammonia a year.

Shell Chemical Corporation is half way through construction work on its new Norco, La., plant to produce allyl chloride, a chemical ingredient of glycerine, and epichlorohydrin, used to make Shell's "epon" resins and D-D soil fumigant. The plant, located near New Orleans, will cost an estimated $8.5 million.

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South America Gets New 10,000-Barrel Refinery

Completion of South America's newest thermal refinery was signified recently by ceremonies dedicating the new Rio De Janeiro facilities designed and engineered for Refineria de Petroleos de Manguinhos, S.A.

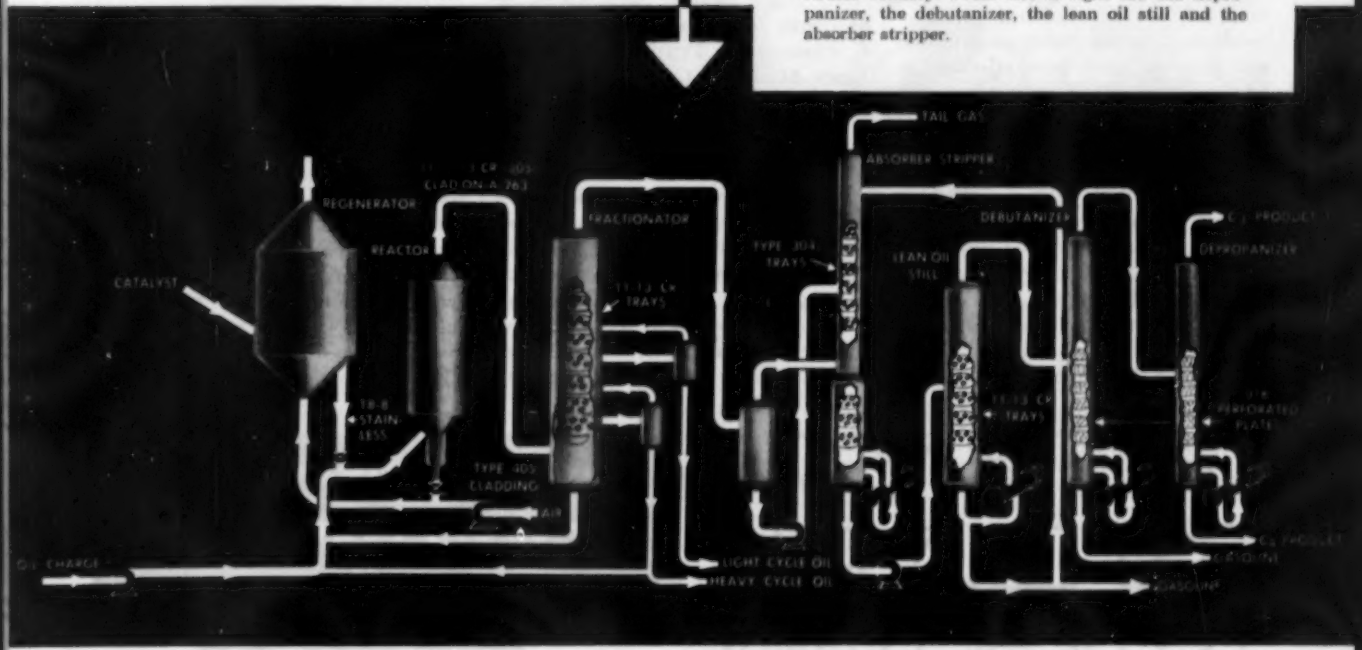
Financed by private capital, the new 10,000-barrel-a-day refinery was designed to operate on East Venezuelan (Oficina) crude oil. In this new integrated refinery, all major process operations have been coordinated into one combination refining battery where certain process steps share common pieces of equipment. All processes are thermal; no catalytic operations are involved.

Individual processes incorporated in the combination unit are: crude topping, light gas oil cracking, reduced crude visbreaking and light ends recovery. The unit has also been designed for the future addition of naphtha reforming facilities and operation on Arabian crude oil.

All major above-ground processing units and operation sections of the offsite facilities were completed in only nine months, with construction undertaken by Brazilians operating with the guidance of The Kellogg Pan American Corporation.

HOW GULF USES STAINLESS STEEL in a fluid catalytic cracking unit

GULF OIL'S fluid catalytic cracking unit at its Port Arthur refinery. From left to right are the depropanizer, the debutanizer, the lean oil still and the absorber stripper.



THE fluid catalytic cracking unit diagrammed here was built in 1951 for the Gulf Oil Corporation's Port Arthur, Tex., refinery. With the help of Stainless Steel—used extensively in trays and piping—this unit handles 65,000 barrels of prepared charging stock daily.

The flow chart shows the various grades of Stainless used in different parts of the unit. Trays in the absorber stripper are Type 304 Stainless Steel, while tray plates in the debutanizer and in the depropanizer are Type 316.

Such careful selection of grades is extremely important in obtaining the maximum corrosion resistance and long life from Stainless Steel. Properly applied, Stainless Steel is one of the most important tools you can use in keeping your refinery operations on stream at all times.

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Who's Meeting . . .

SAE at Detroit . . .

. . . **A lot** still has to be done in research on the proper lubricants for aircraft turbine engines. The broad temperature range imposes a temperature limitation problem on the lubricants. Synthetic lubricants have a considerably higher limiting temperature than the petroleums. For the higher temperature, solid or gaseous lubricants are under consideration because of better thermal stability. Solids such as molybdenum disulfide and graphite have been effective in lubrication of rolling contact bearings at high temperatures (500 to 1000 F.). Similar gases have been used as lubricants at high temperatures. Preliminary studies of the external pressurized air bearing at 1000 F. showed that a nonrotating bearing supported loads in a stable manner at this temperature (R. L. Johnson and Edmond E. Bifson, Louis Flight Propulsion Laboratory, Cleveland, Ohio).

. . . **The development** of commercial turbine powered aircraft will depend greatly on fuel selection. Trans Canada Air Lines narrowed its choice of turbine fuels for its Viscount operation down to JP-4 wide-cut fuel and a minus 55 F. freezing point aviation kerosine. Of the two it picked the JP-4 as having the best combination of desirable attributes, especially for its higher spontaneous ignition temperature, and its lesser tendency to creep and a built-in safety factor in its minus 76 F. freezing point (Paul E. Lamoureux, Trans Canada Air Lines, Montreal, Canada).

. . . **From** the point of view of the aircraft manufacturer, operation with a fuel such as kerosine or heavier is very attractive from a cost standpoint. Any fuel heavy enough to require much engine development in order to accommodate it or require heating in the airplane tanks will lose much, if not all, of its advantage. Whatever the fuel is it must be carefully controlled and carried in very large supply. Operation on a fuel as heavy as kerosine or heavier seems desirable but depends on the ability of the refiners to produce the fuel slightly different from those currently in wide use, the ability of the engine manufacture to adapt his engine to it, the ability of the aircraft designer to make provisions for use of fuels of marginal freezing points and the requirements of the route over which the aircraft operates (C. A. Weise, Douglas Air Craft Company, Inc., Santa Monica, Calif.).

. . . **Refiners** are giving lots of attention to volatility in motor fuels. Recent studies show that Reid vapor pressure alone is not an adequate procedure for controlling the vapor locking tendencies in motor gasolines. In fact some gasolines of normal vapor pressure have a higher vapor locking tendency than some gasolines of above normal vapor pressure. A few car models are exceptionally prone to vapor lock. To keep these critical cars out of vapor lock difficulties would require uneconomic fuels. More careful fuel system design is required to avoid the production of critical cars. The average motor gasoline in many

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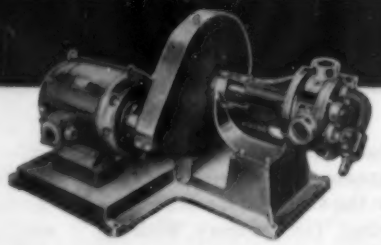

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Who's Meeting . . .

areas in the U. S. can be made more volatile with safety provided a proper control procedure is used. In some areas the average gasoline approaches a safe level established by field tests. The production of more volatile gasolines will save money for the motorist. In some areas, however, arbitrary restrictions prevent the refiner from making these savings available to the motorist. To help overcome this situation the ASTM and federal specifications for motor gasoline should be altered to include a more realistic control of vapor locking tendencies in motor gasoline (D. P. Heath and R. H. Thena, Socony-Vacuum Oil Company, and Gilbert Way, Ethyl Corporation).

. . . As one of the most talked about developments in American industry, automation is getting more attention every day from many varied interests. Though the impression has been created in some sources that a large number of automotive factories are now completely automatic, this is not the case, as the completely automatic factory is still some distance in the future. However, the future of automation is encouraging. It is also believed that automation will create more, not less, jobs in the industry. For example, the growth of automation will create many new higher skilled jobs in the electronic, machine tool and other industries engaged in building new automative plants. Those industries, in turn, will have to expand their own facilities in order to meet the growing demand, and that in turn will provide jobs in the industries which provide the tools and plants of the electronics and machine tool builders (G. G. Murie, Ford Motor Company, Detroit).

. . . **Studies** are now available on the distribution and effects of automotive exhaust gases in the Los Angeles area. These studies show that the removal of all other sources of hydrocarbons from refineries and from the distribution of gasoline will not lower the concentration of hydrocarbons in the downtown area and the north central section of the county sufficiently to relieve the eye irritation, crop damage effects and high ozone content of the air in those areas. The marked influence of traffic in the early morning hours increases the concentration of hydrocarbons to levels which cannot be tolerated in the Los Angeles atmosphere. On the basis of the total studies, it has been concluded that hydrocarbons must be removed from the exhaust gases of the automobile. Furthermore, the efficiency of removal must be extremely high. The air pollution control district recommends that engineering studies seeking to remove hydrocarbon vapors from exhaust gases strive for a 90 percent over-all removal under conditions of operations experience in heavy traffic (Gordon P. Larsen and John C. Chipman and Erwin K. Kauper, Air Pollution Control District, Los Angeles).

. . . **It has** been found that the most typical characteristic of the Los Angeles smog is its strong oxidizing effect. It has been established that a substantial part of the oxygen consists of ozone. Fundamental research has shown that the ozone generating capacity of automobile exhaust gases occurs by irradiation of dilute exhaust gases from the cruising and accelerating phases of automobile operations. Exhaust gases from idling and decel-

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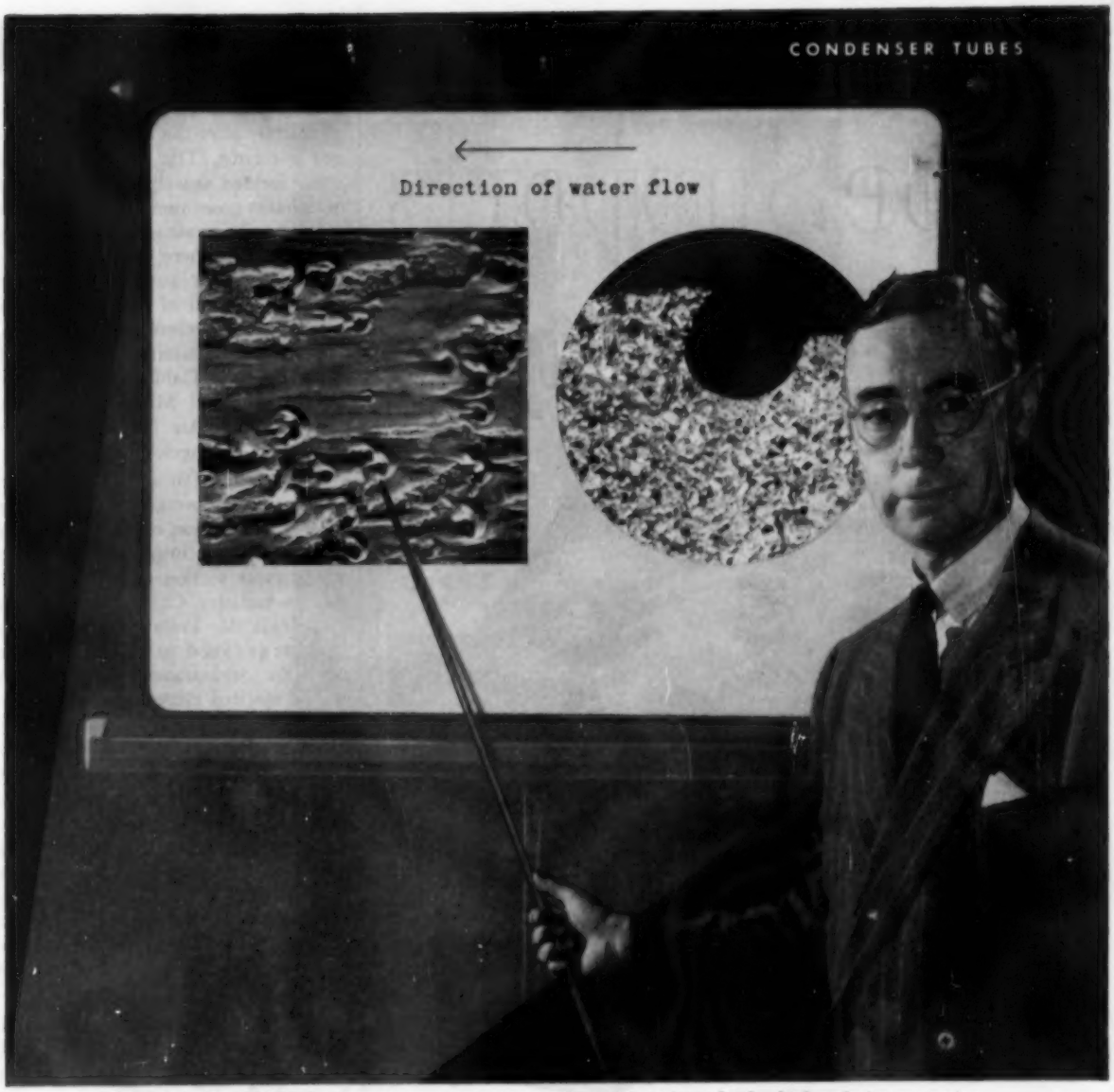

Illustration at left shows impingement corrosion of an Admiralty tube by high velocity sea water containing air bubbles. At right, longitudinal section through part of horseshoe-shaped pit is shown.

AIR BUBBLES: what causes them, how they affect condenser tubes

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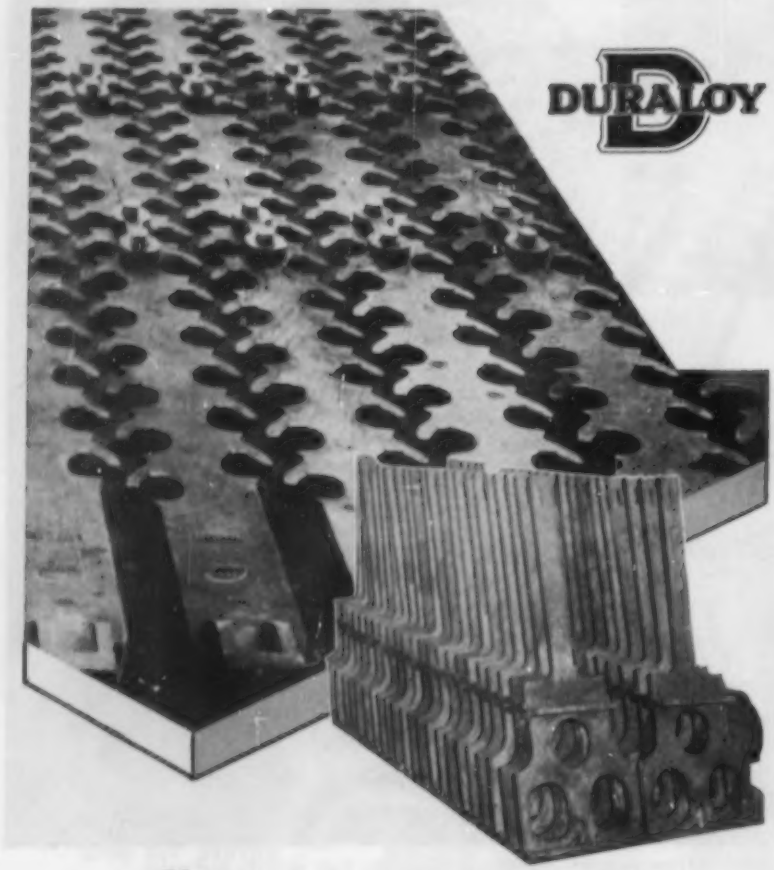

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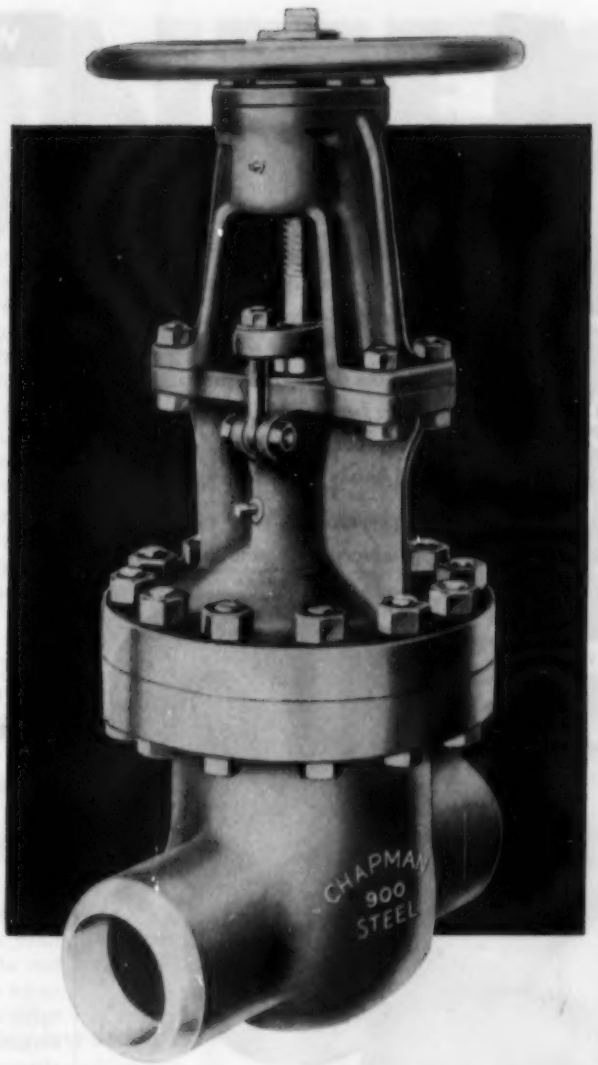
Who's Meeting . . .

eration phases formed ozone photochemically after the addition of nitrogen dioxide. The concentration of ozone formed as well as concentration of exhaust gases used are of the same order as those measured in the Los Angeles atmosphere. These investigations show that automobile exhaust gases are capable of forming ozone in the air and therefore, it is considered as a definite source of smog (A. J. Haagen-Smith, California Institute of Technology and Margaret M. Fox, L. A. County Air Pollution Control District, Los Angeles).

There has been such a misrepresentation of facts on smog that despite government action on the problem, a foundation was organized representing a cross section of southern California industry. Called the Southern California Air Pollution Foundation, it is organized as an independent scientific organization supported by public spirited citizens to help determine the cause of smog and implement its elimination. The foundation actually got under way on February 1, 1954, when Dr. Lauren B. Hitchcock was appointed president, manager and director of the foundation. The foundation is basically a research team of five scientists supplemented by the necessary related personnel (W. L. Faith, Southern California Air Pollution Foundation, Los Angeles).

. . . **Standard Oil Development** engineers have been studying both motor oil quality and gasoline quality to meet the increased compression ratios in automobiles. Great strides have been made in minimizing deposits caused by the lubricants through the widespread introduction of specially formulated low deposit forming motor oils. The engineers now show what can be gained by tailor-making the gasoline also. According to their most recent road tests, increasing fuel volatility by the elimination of high boiling materials reduces the octane requirement of high compression-ratio engines. Volatile fuels in combination with multiviscosity lubricants give substantially reduced octane requirements when compared with conventional type fuel lubricant combinations. Based on available data, it appears that it will be entirely feasible to operate 9½ to



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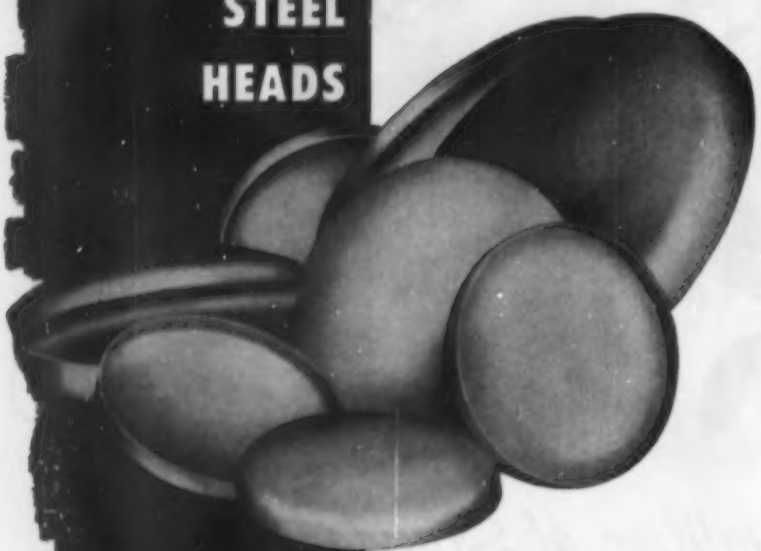
Fabricators rely on G. O. Carlson, Inc. for stainless steel heads produced to exact specifications and for other components of stainless steel tanks. Shells, flanges, rings, pads as well as spun or press-formed heads are readily available as a packaged service. This eliminates the need of multiple ordering from several suppliers and places responsibility in the skilled hands of Carlson specialists.

Carlson stainless steel heads are produced in a wide range



of sizes and gauges to ASME and standard specifications. Many styles of forming dies are available. There's an up-to-date folder describing these dies—write for your copy now!

Stainless Steels Exclusively

G. O. CARLSON, INC.

Plates • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

THORNDALE, PENNSYLVANIA

District Sales Offices in Principal Cities

Who's Meeting . . .

1 and 10 to 1 compression-ratio cars on 98 to 99 research octane fuel with the proper volatility using a multi-viscosity lubricant. As the use of volatile fuels and multi viscosity lubricants become more general, it should be possible to increase compression ratios without a corresponding increase in quality (C. L. Fleming, N. V. Hakala, L. E. Moody, R. W. Scott and C. O. Tongberg, Standard Oil Development Company, Linden, N. J.).

. . . **A new** detergent has been developed in the formation of motor oil sludge at low temperatures. It is a copolymer of lauryl methacrylate and diethylaminoethyl methacrylate. This detergent is most effective in oils containing water, carbon or acid constituents (E. C. Ballard, DuPont Petroleum Laboratory, Wilmington, Del.).

Instrument Symposium at Texas A & M . . .

. . . **One big** problem facing Spencer Chemical was the selection of instruments for sub-zero temperature application in its liquid air separation unit. The company selected the DC EMF type temperature instrument. In selecting an EMF type you can have any arrangement, type or number of thermocouples to one instrument as long as they are of the same calibration. Also you can enclose the extension leads to more than one instrument and one conduit or duct and not encounter stray currents. This is not possible while using resistant bulb type thermometers for any time you place extension leads to more than one resistance instrument and one conduit you are going to be troubled with stray current (J. C. Evans, Spencer Chemical Company, Vicksburg, Miss.).

. . . **The Baytown** refinery has built up a strong case for a central system of instrument air conditioning. It was concluded that over a period of five years before this system was installed approximately $90,000 could be attributed to loss because of a non-integrated instrument air system. With the expenditure of $59,000, the system for centralization and conditioning of air has proved successful in the past six years. During a freeze in 1951 the refinery process units were unaffected, although an adjacent tol-

CONTEST

for Capable Engineers only

Guess the name of this manufacturer of vacuum equipment

PRIZES:

1. **GRAND PRIZE** — Trip around the universe.
2. **SECOND PRIZE** — Option on the Brooklyn Bridge.
3. **THIRD PRIZE** — Six pairs of three-legged overalls.
4. **ONE THOUSAND RUNNER-UP PRIZES** — one thousand ouija boards.

CLUES:

1. Company founded in 1917.
2. Both original founders still active in the business.
3. Each founder has a son thoroughly trained in engineering who is also active in the business.
4. The company has specialized in jet vacuum equipment more than any one firm.
5. Has made hundreds of jet cooling units in capacities up to 3000 tons of refrigeration.
6. Makes an extensive line of other jet equipment including jet mixers, jet heaters, jet absorbers, jet pumps, and jet fume scrubbers.
7. Has designed and built thousands of barometric condensers in standard and a great variety of special materials.

Why, of course it's

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CHILLVACTOR UNITS • EVACTOR STEAM JETS • CONDENSING EQUIPMENT

For more data on advertised products, use Readers' Service Cards, last page.

Only Sound Steel Passes This "Radar" Test

This ultrasonic reflectroscope performs one of the many quality control tests employed by Sheffield to assure you sound alloy steel. It sends high frequency waves into steel to locate possible physical defects.

Sheffield Alloy Steels Cut Production Costs

You're a consumer – so you're interested in getting steel products that do a better job longer. Or you're a manufacturer – on the lookout for ways of cutting costs while making better products and values.

From either viewpoint, Sheffield alloy steels offer big benefits. Wherever greater strength per unit of weight is a factor, alloy steel effects economies in production, right down to the last freight bill. And its resistance to corrosion extends the benefits of alloy steel over a longer service life.

Sheffield applies the most advanced chemical, electronic and mechanical testing procedures. They uniformly control quality at specified levels. Sheffield's strategic location makes it possible for us to supply you "custom-tailored" alloy steels with big savings in both shipping time and money.

If you're a manufacturer or otherwise engaged in the metal working industries, write for your copy of Sheffield's new Alloy Steel Book. It covers concisely the subject of Sheffield alloy steels and how to use them to best advantage.

SHEFFIELD STEEL

DIVISION

ARMCO STEEL CORPORATION

SHEFFIELD PLANTS: HOUSTON KANSAS CITY TULSA

Who's Meeting . . .

uene unit not in the system was forced to shut down due to icing (R. L. Dockendorff, Humble Oil and Refining Company, Baytown, Texas).

. . . **One refinery** has found application for mercuryless nanometers in bad catalyst control problems. The catalyst does not flow back into the mercuryless instrument; and in case it does fill the line, it can be blown out without disassembling the instrument. Particular applications included an installation with one pressure tap above the precipitator slide valve and the other cap below the slide valve. In catalyst control problems it was found that it is advantageous to locate the instrument at or above the upper pressure tap, which helps prevent the instrument taps from plugging in cases of bleed air failure. In case the bleed air trouble is corrected, it has a directional tendency to purge out what small amount of catalyst that has accumulated in the line (E. D. Mattix, Cities Service Refining Corporation, Lake Charles, La.).

In the Future . . .

. . . **Welding** developments have inspired the American Welding Society to sponsor a national heavy industry show (Kansas City, June 8 to 10) . . . Among the speakers at the Fourth World Petroleum Congress will be many famous American names in petroleum (Rome, Italy, June 16 through 15) . . . The ASME's anniversary meeting will feature a program devoted to the engineer and his communications (New York, February 16) . . . Fundamentals of corrosion are to be stressed rather than consideration of solutions to specific problems during the three-day University of Tennessee corrosion conference (March 1 through 3, Knoxville) . . . The 1955 National Materials Handling Exposition will emphasize handling systems rather than individual pieces of equipment (Chicago, May 16 through 20) . . . The Texas Water and Sewage Works Association plans a comprehensive short school in pollution and waste disposal (Texas A & M, March 7 through 9).

Calendar of Meetings Appears on Next Page

After 14 years' research in the laboratory and scores of industries, Dragert's chemists have developed the magic, ALL-PURPOSE, *easy-to-use* thread compound called "BIG D." Sold on an unconditional MONEY-BACK GUARANTEE, "BIG D" the *only 90%* TRUE METALLIC LEAD thread formula (not lead oxide) — is *revolutionary* in that besides providing a lasting leak-proof seal against the most punishing pressures and hellish temperatures of gas, oil, water and all hydrocarbons, "BIG D" *spins a flawlessly smooth, protective lead-plating,* ISLAND HIGH, *in all types of threads* . . . and this chemically perfect, lubricant-seal of *specially atomized, pure, pig lead, scientifically insures phenomenally increased thread life* . . . pipe-joints, nuts, studs, flanges, anything threaded, CAN'T *gall, burn, freeze, seize,* or *twist-off* . . . ALWAYS PERMIT FREE REMOVAL. Finally, "BIG D" is almost unbelievably economical, affording MAXIMUM *sealing and thread life with* MINIMUM *doping.*

C. H. DRAGERT CO., INC., (23rd Year in Business)
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Dallas, Texas

Gentlemen:
Entirely without cost or obligation, please send me a one-pint sample can of Dragert's "BIG D" 90% Metallic Lead ALL-PURPOSE Thread Compound, and descriptive brochure, "The Inside Dope on Dragert's 'BIG D'."

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25,000 LBS. TORQUE-TESTED

For more data on advertised products, use Readers' Service Cards, last page.

STOP CORROSION
with BIRD-ARCHER AMINE TREATMENT

Unretouched photograph shows the ravages of corrosion on condensate return lines.

Corrosion of piping in steam and condensate return lines is an expensive two-way headache. (1) It leads to large outlays for pipe replacement and maintenance. (2) It often results in plugged return lines and traps due to the solid products of corrosion. Bird-Archer Amine Treatment effectively eliminates these troubles at low cost.

Here's how. Amines are fed into the boiler or into the steam and condensate systems. The amines raise the pH value of the condensate and also tend to inhibit equipment-destroying corrosion through surface protection of the metal itself. In scores of plants, this Bird-Archer system has more than paid for itself by substantially cutting replacement and maintenance costs.

BA-902

Bulletin CP 100 gives all the facts on Bird-Archer Amine Treatment. Write for your copy.

LABORATORIES ENGINEERS • CHEMISTS

BIRD-ARCHER WATER TREATMENT

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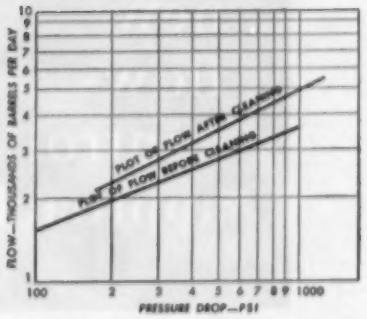
IN MEXICO: Calderas y Accesorios, S. A., Amsterdam 291, Mexico, D. F.

CALENDAR OF MEETINGS

FEB.	
13–18	ASTM Committee D-2 on Petroleum Products and Lubricants, Rice Hotel, Houston.
16–17	American Petroleum Institute (Division of Marketing, Lubricating Committee), Sheraton-Cadillac Hotel, Detroit.
25	Natural Gasoline Association of America (Regional Meeting), Scharbauer Hotel, Midland, Texas.
MAR.	
6–11	Texas Water and Sewage Works Association (37th Annual Short School), College Station, Texas.
7–11	National Association of Corrosion Engineers, (Annual Conference and Exhibition), Palmer House, Chicago.
20–23	American Institute of Chemical Engineers, Kentucky Hotel, Louisville, Ky.
24–28	American Gas Association (Gas Supply, Transmission and Storage Conference), Wm. Penn Hotel, Pittsburgh.
28–April 1	American Society for Metals (Ninth Western Exposition and Congress), Pan American Auditorium, Los Angeles.
30–April 1	American Power Conference, Sherman Hotel, Chicago.
APRIL	
4– 8	American Petroleum Institute (Safety and Fire Protection Committees, Midyear Meeting), Jung Hotel, New Orleans, La.
5– 7	Corrosion Control Short Course, Sponsored Jointly by University of Oklahoma and the Central Oklahoma Chapter of NACE), University of Oklahoma, Norman, Okla.
13–15	Conference on Biological Waste Treatment, Manhattan College, New York.
13–15	National Petroleum Association (52 Semi-Annual Meeting), Cleveland Hotel, Cleveland.
13–15	Natural Gasoline Association of America (Annual Convention), Baker and Adolphus Hotels, Dallas, Texas.
13–15	American Society of Lubrication Engineers (Annual Meeting and Lubrication Exhibit), Hotel Sherman, Chicago.
18–19	Third National Air Pollution Symposium, Pasadena, Calif.
18–20	American Society of Mechanical Engineers (Spring Meeting), Lord Baltimore Hotel, Baltimore, Md.
20–22	Petroleum Industry Electrical Association (Annual Conference), Shamrock Hotel, Houston.
MAY	
1– 4	American Institute of Chemical Engineers, Shamrock Hotel, Houston.
1– 4	Liquefied Petroleum Gas Association (Annual Convention), Conrad Hilton Hotel, Chicago.
2– 4	American Petroleum Institute (Evaporation Loss Committee and Subcommittee Meetings), Edgewater Beach Hotel, Chicago.
9–10	American Gas Association (Gas Supply, Transmission, Storage Conference), Wm. Penn Hotel, Pittsburgh.
9–12	American Petroleum Institute (Division of Refining, Midyear Meeting), Jefferson Hotel, St. Louis, Mo.
14–22	World Wide Chemical Plant and Equipment Exposition and Congress, Frankfurt, Germany.
16–18	American Petroleum Institute (Division of Marketing, Lubrication Committee), The Greenbrier, White Sulphur Springs, W. Va.
16–20	National Fire Protection Association, Netherlands Plaza Hotel, Cincinnati, Ohio.
18	Chemical Market Research Association (Annual Business Meeting), Hotel Plaza, New York.
23–27	Conference on Mass Spectrometry, Sponsored by American Society for Testing Materials Committee E-14, Mark Hopkins Hotel, San Francisco.
30–June 1	Chemical Institute of Canada (38th Annual Conference and Exhibition), Quebec City, Canada.
JUNE	
5– 9	Canadian Gas Association (Annual Meeting), Sheraton Brock Hotel, Niagara Falls, Ont., Canada.
6–15	Fourth World Petroleum Congress, Rome, Italy.

80-MILE LPG LINE CLEANED CHEMICALLY

DOWELL restored original capacity without digging up the line



Graph shows a 40.6% increase in the volume of fluid handled by the line after chemical cleaning.

An 80-mile LPG* line supplying a petrochemical company suffered a serious pressure drop and a substantial decrease in capacity because of iron oxide deposits.

Dowell engineers pumped specially prepared chemical solvents into one end of the 4" line, treating the entire 80-mile length as a single unit. No intermediate entry points were needed, so no digging was necessary to complete the cleaning. The line's original capacity was restored and the job finished in only ten days.

Many types of lines, heat exchange and process equipment have been cleaned the Dowell way. Here's how: Dowell engineers bring all the necessary equipment and solvents right into your plant. Dismantling of the unit to be cleaned is kept to a minimum, since solvents are introduced through regular connections. Bends, elbows, valves and other normally inaccessible surfaces are reached effectively. Inhibitors are added to protect against metal loss during cleaning. With extremely hard scale, jet moles and pipe line pigs supplement chemical action. Most jobs take only a few hours. Often, equipment can be cleaned while in operation.

To learn how Dowell can help you solve your particular cleaning problems, call your nearest Dowell office; or write directly to DOWELL INCORPORATED, Tulsa 1, Oklahoma, Dept. B-31.

*Liquefied Petroleum Gas

cleaning services for industry

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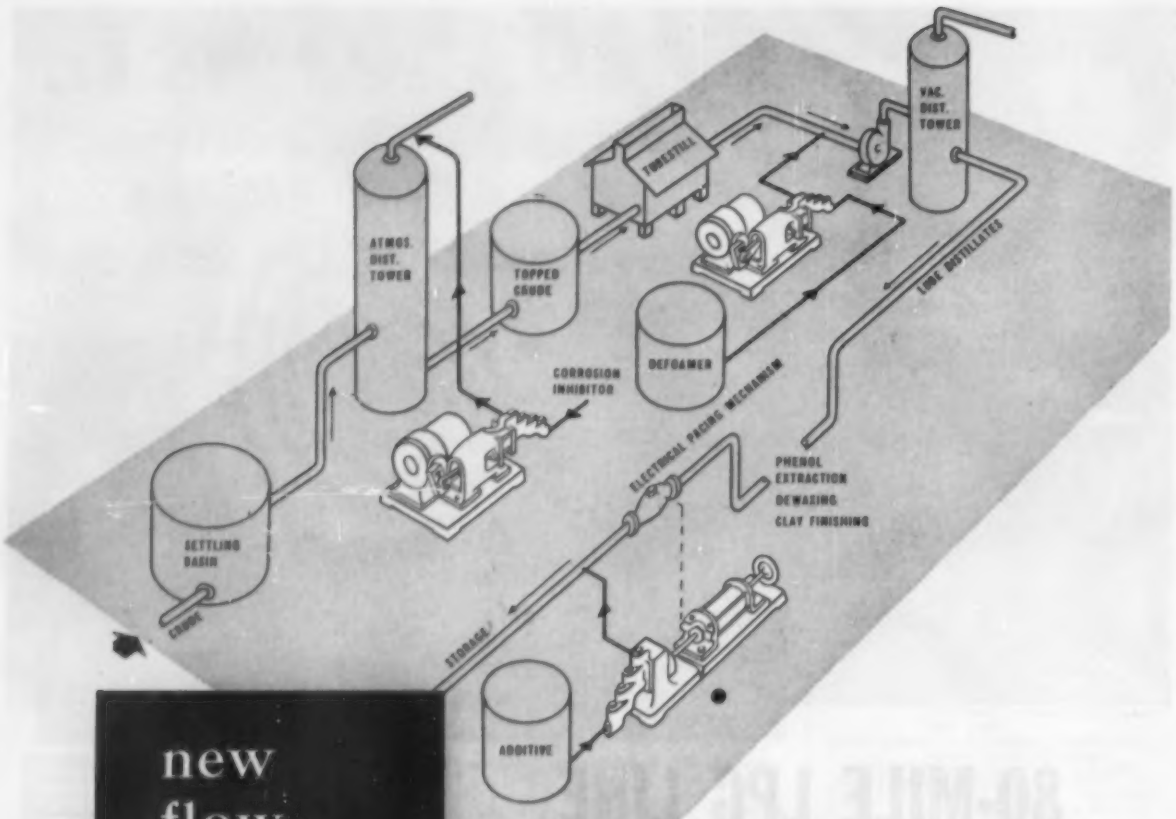


new flow-control approach

guards product quality

. . . cuts chemical costs

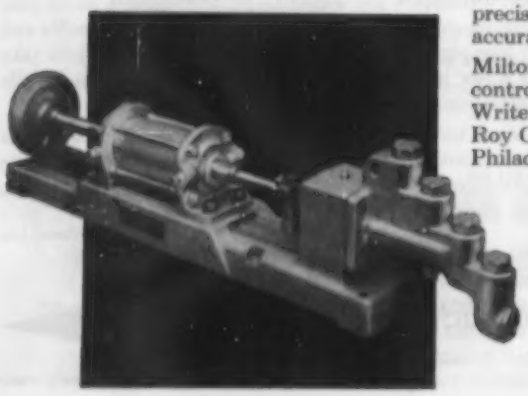
controlled volume pumps are flow control instruments

A SIGNIFICANT advance in low-capacity flow control is making big news in the petroleum processing industry. Corrosion inhibitors, octane appreciators, defoamers, demulsifiers, reagents, and other chemical additives are being metered to process with new accuracy by Milton Roy *controlled volume pumps*. By controlling flow more precisely, this new approach provides better quality control, positive corrosion control, and reduces chemical costs substantially.

Here's why. Controlled volume pumps are actually flow control *instruments* . . . particularly valuable for low-capacity flows. They precisely meter volatiles, acids, even heavy oils and sludges to an accuracy of within 1%!

Milton Roy offers you long experience in handling low-capacity flow control problems . . . in engineering complete chemical feed systems. Write for technical information. Or, send your problems to Milton Roy Company, *Manufacturing Engineers*, 1300 East Mermaid Lane, Philadelphia 18, Pa.

● *Air-powered controlled volume pump meters fuel oil additive in precise proportion to main line flow rate. Other two models are standard motor-driven controlled volume pumps on corrosion inhibitor feed and defoamer control.*



Engineering representatives in the United States, Canada, Mexico, Europe, Asia, South America, and Africa.

milton Roy
CHEMICAL FEED SYSTEMS

What's Happening in the Industry . . .

Goodrich Chairman Would Reduce Rubber Stockpile

Reduction of government expenditures by ending further additions to the national stockpile of crude rubber has been proposed by John L. Collyer, chairman of the board of B. F. Goodrich Company, Akron, Ohio.

At the same time Collyer would dispose of crude rubber now in stockpile which might be in excess of tonnage required for a national emergency.

In a letter to Dr. Arthur S. Flemming, director, Office of Defense Mobilization, the B. F. Goodrich executive said that "calculations made from published, non-classified figures indicate that the U. S. government owns, within our country's borders, more than 1,200,000 long tons of crude rubber having an estimated cost of $825,000,000. If so, the government stockpile, plus private stocks in the U. S., now total more than 1,300,000 long tons."

This stockpile, couple with capacities for the production of man-made rubber in the U. S., would take care of the country's military and civilian needs during an all-out war of six to possibly eight years' duration, assuming that the rubber stocks would not be destroyed, or the synthetic rubber plants crippled by the enemy, Collyer stated.

Delhi, Taylor Oil Merger Approved by Stockholders

An agreement of merger of Delhi Oil Corporation, of Dallas, Texas, and Taylor Oil & Gas Company, of Taylor, Texas, has been approved by a vote of the stockholders of the two companies.

Delhi stockholders voted more than 87 percent in favor of the merger and Taylor more than 84 percent in favor. Final approval was given by the board of directors of each company. The consolidation was to have gone into effect early this month.

Negotiations for merging the two firms had been under way for about two years.

Taylor owns a refinery at Corpus Christi and one-half interest in another at Port Isabel, Texas. The Corpus Christi plant has a thruput of about 40,000 barrels a day.

SAE Award to MacKenzie

Kenneth G. MacKenzie, of Old Hill Farms Road, Westport, Conn., has been awarded the Society of Automotive Engineers Certificate of Appreciation for his outstanding contribution to the work of the society's Fuels and Lubricants Technical Committee.

Co-Ops Increase Business

New figures recently released by the Agriculture Department show that 2654 cooperative associations did a gross petroleum business of $436,274,000 in fiscal 1953 (period from July 1, 1952 through June 30, 1953). The 1953 gross represents a $14.7 million gain over fiscal 1952, when 2657 co-ops did a gross petroleum business of $421,524,000.

API Division of Refining Program Includes Variety of Interesting Topics

Leaders in the refining industry will gather in St. Louis May 9-12 for the twentieth midyear meeting of the Division of Refining of the American Petroleum Institute.

To be held at the Jefferson Hotel, the meeting will include 12 technical group sessions and an open dinner session. Subjects to be taken up include analytical research, corrosion, training, smokes and fumes, product control, pressure vessels, processes, fuels and lubricants, refinery maintenance and petroleum products.

Preliminary program for the meeting follows:

MONDAY, MAY 9, 1955

9 a.m.—Analytical Research

Session developed by C. E. Headington, Atlantic Refining Company, and G. R. Lake, Union Oil Company of California. "Spectrographic Determination of Traces of Nickel and Vanadium in Petroleum Products by Catalytic Ashing Process," J. E. McEvoy, T. H. Milliken and A. L. Juliard, Houdry Process Company. "Flame Spectra of 20 Metals Using a Recording Flame Spectrophotometer," M. Whisman and B. H. Eccleston, U. S. Bureau of Mines. "Determination of Trace Metals in Oil," H. G. Schutze, B. N. Hill, A. E. Walters and J. T. Horeczy, Humble Oil and Refining Company. "An X-Ray Spectrographic Method for the Determination of Vanadium and Nickel in Residual Fuels and Charging Stocks," E. N. Davis and Barbara C. Hoeck, Sinclair Research Laboratories, Inc. "Metal Contaminants vs. Catalytic Conversion," H. W. Cogswell, D. Milsom and A. R. Rescorla, Cities Service Research and Development Company. "Determination of Trace Amounts of Basic and Total Nitrogen in Petroleum Distillates," D. T. Fanale, R. E. Fricioni, D. W. Hutton, R. E. Snyder and R. O. Clark, Gulf Research and Development Company. "The Spectrophotometric Determination of Carbonyl Sulfide in Petroleum Refinery Gases," F. J. O'Hara, W. M. Keeley and H. W. Fleming, The Girdler Corporation.

9 a.m.—Corrosion

Session developed by C. F. Pogacar, Atlantic. "The Use of Neutralizers and Inhibitors to Combat Corrosion in Hydrocarbon Streams," R. J. Hafsten and K. R. Walston, Standard Oil Company of Indiana. "Deterrence of Hydrogen Blistering at a Fluid Catalytic Cracking Unit," B. W. Neumaier and C. M. Schillmoller, Richfield Oil Corporation. "Cooling Water Treatment for Corrosion Control Pays Off," J. W. Dilliplane, J. J. Hur and D. A. Wrigley, Atlantic. "A Study of the Deterioration of Large Concrete Sewers," author from Esso Standard Oil Company to be named later.

2 p.m.—Analytical Research

Session by Headington and Lake. "Analytical Laboratory Operation and Control Utilizing Machine Punched Card Procedure," L. M. Addison, E. H. Spencer and E. M. Charlet, Esso Laboratories. "A New Look at the Composition of Lubricating Oil," F. W. Melpolder, R. A. Brown, T. A. Washall, W. Doherty and C. E. Headington, Atlantic. "A Differential Infrared Method for Quantitatively Determining Specific Hydrocarbons," O. Easton and C. W. Key, Richfield. "Determination of Six and Seven Carbon Naphthene in Reformer Charged Stock," Subcommitte on Determination of Naphthenic Hydrocarbons (COAR), C. C. Martin, S. S. Kurtz, Jr., and Collaborators, Sun Oil. "Colorimetric Determination of Low Concentrations of Oxygen in Gases," G. S. Stafford, J. E. Puckett and M. D. Grimes, Phillips Petroleum Company. "Laboratory Methods for the Determination of Evaporation Losses of Petroleum Products," J. Holowchak, Standard Oil Development Company. "The Polarographic Determination of Elemental Sulfur in Crude Oil and Petroleum Fractions," J. F. Miller and W. Hubis, Mellon Institute of Industrial Research, and H. V. Drushel and R. O. Clark, Gulf Research and Development Company. "Analytical Distillation in Miniature Columns, II. Column Performance at Atmospheric Pressure and 330 mm Hg.," A. G. Nerheim and R. A. Dinerstein, Standard.

2:00 p.m.—Training

Presiding: C. C. Tate, Phillips. Session developed by E. R. Laminack, Socony-Vacuum Oil Company. "The Place of Effective Communications in Employe Development," M. E. Stone, Sinclair. "A Procedure for Training Process Unit Operating Personnel," O. C. Day, Esso Standard. "Organization Planning in Relation to Management Development," Lounsbury Fish, Standard Vacuum Company.

TUESDAY, MAY 10

10 a.m.—Smoke and Fumes

Session developed by Vance N. Jenkins, Union. "The Formation of Ozone in Polluted Atmospheres," L. M. Richards and M. D. Thomas, Stanford Research Laboratories. "The Concentration of Ozone in Representative American Cities," J. Cholak, L. J. Schafer and D. Yeager, University of Cincinnati. "Reactions Involving Ozone, Nitrogen Dioxide and Organic Compounds at Low Concentrations in Air," Philip L. Hanst, Edgar R. Stephens and William E. Scott, The Franklin Institute.

2:00 p.m.—Product Control

Session developed by W. K. Bergen, Ohio Standard. Panel discussion: "New Horizons in Product Control," T. Keith Glennan, Case University, panel leader.

7:00 p.m.—Pressure Vessels

Session developed by N. J. Rese, Socony-Vacuum. "Considerations Affecting More Economic but Equally Safe Pressure Vessel Construction Utilizing Either Present-Day Ductile Materials or New High

Hallanan Tells Industry To Fight Gas Controls

No official position has been taken by the National Petroleum Council on proposals to remove natural gas producers from federal control, but several members of the organization praised recent remarks by Council Chairman Walter Hallanan, in which he said that the industry "has come under the most serious threat of its entire existence" as a result of the Supreme Court's ruling in the Phillips case.

Speaking at a dinner meeting in Washington, Hallanan said that bringing natural gas production under control of the Federal Power Commission could not be viewed in any other light than as an approach to complete government regulation. He urged the industry to fight what he called regimentation .

"This effort to keep natural gas production under federal control is just another crucial battle in the never-ending war between free enterprise and socialism," he said. "If it is to the advantage of the consumer for the government to fix the price of gas at the well-head, it is to his even greater advantage to fix prices of coal, wheat, wool and automobiles at the point of production."

The government has not asked the council for its recommendations on the natural gas problem, nor has the council passed any resolution on the matter.

Defense Post to Macauley

John Blair Macauley has been named Deputy Assistant Secretary of Defense (for research and development) by the Defense Department. He will be on leave from post with Ethyl Corporation as director of technical coordination. Macauley will fill a post similar to one now held by Dr. D. P. Barnard, research coordinator for Standard Oil Company (Indiana), who is expected to return to his company soon.

What's Happening. . .

Strength Less Ductile Materials," J. J. Murphy, C. R. Soderberg and D. B. Rossheim, The M. W. Kellogg Co. "Mechanical Properties and Weldability of Six High Strength Steels Applicable to Pressure Vessels," R. D. Stout and J. H. Gross, Lehigh University.

WEDNESDAY, MAY 11

9:00 a.m.—Processes

Session developed by C. L. Thomas, Sun Oil. "Hydrogene—Its Markets and Potential Uses," Robert L. James, A. D. Little, Inc., "Hydrogen Recovery from Catalytic Reformer Off-Gases," Carl Pfeiffer and Henry J. Sandler, Catalytic Construction Company. "Upgrading Distillate Fuels by Hydrofining," W. J. Zimmerchied, R. A. Hunt, Jr. and W. A. Wilson, Indiana Standard. "The Gulf HDS Process for Upgrading Crudes and Residues," Jerry McAfee, C. W. Montgomery, Joel H. Hirsh and W. A. Horne, Gulf Research and Development.

9:00 a.m.—Fuels and Lubricants

Session developed by T. B. Rendel, Shell Oil Company. "Ignition of Fuels in a Constant Volumn Bomb," R. W. Burns, Bureau of Mines; M. A. Elliott, Illinois Institute of Technology, and H. M. Trimble, Phillips. "Report on the 1953-54 Surveys on Vapor Lock and Hot Stalling and Starting Difficulties," Coordinating Fuel and Equipment Research Committee and Coordinating Research Council Inc. "Incentives for Precise Test Methods: The Case of a New Basic Knock Test Unit," M. R. Morrow, Humble.

2:30 p.m.—Processes

"Hydrogene Recovery and Purification from Refinery Off Gases," J. T. Hugill and F. G. Kerry, Spaco Inc. "Hydro Pretreatment of Catalytic Reformer Feed," D. H. Stevenson and G. A. Mills, Houdry Process Corp. "Unifining—A Proven Refining Technique," Davis Reed and M. J. Sterba, Universal Oil Products Company, and F. L. Hartley and G. H. Hemmen, Union. "Vapor Phase Hydrodesulphurization Applied to Cracked Naphthas and Light Straight-Run Intermediates," G. E. Liedholm, D. H. Sarno and M. D. Abbott, Shell Development. "Hydrofining and Fluid Coking for Processing High Sulfur Heavy Crude in a Low Sulfur Refinery," SOD.

7:00 p.m.—Open Dinner Session

Presiding: E. B. McConnell, vice president for refining, API, and Ohio Standard. Session developed by C. E. Davis, Shell. Opening Remarks: E. B. McConnell. Addresses to be announced.

THURSDAY, MAY 12

9:00 a.m.—Refinery Maintenance

Presiding: R. R. Irwin, Socony-Vacuum. Session developed by D. R. Johnson, Continental Oil Company. "Planning and Building the Refinery for Minimum Maintenance," R. E. Redfield, Socony-Vacuum. Prepared Discussion: "Thermal Cycling Tests of a Hot Spot on a Vessel," P. N. Randall and H. A. Lang, Indiana Standard. "Scheduling Refinery Maintenance," Gulf Oil. "Use of Contractors' Maintenance Crews for Hauling Large-Scale Refinery Turnarounds," J. W. Towler, Union Oil.

2:00 p.m.—Petroleum Products

Session developed by P. C. White, Pan American Refining Corporation. "Prospective Labeling of Petroleum Products," L. C. Beard, Jr. and A. C. Pabst, Socony-Vacuum. "Changing Distribution Pattern of Refinery Products," "The Significance of Test Methods and Specifications on Product Control," "Vapor Pressure-Temperature Correlations for Petroleum Hydrocarbons," SOD.

Revised Specification Raises Octane Level

Recommendations for a revision of the Tentative Specifications for Gasoline (D439) which raised the minimum octane number requirements for regular- and premium-priced gasolines were recently accepted by the American Society for Testing Materials Administrative Committee on Standards.

These requirements are reviewed regularly by Technical Committee A of Committee D-2 on Petroleum Products and Lubricants and compared with the octane number levels of those gasolines reported in the National Motor Gasoline Survey. The 1953-54 winter survey revealed a change in octane number level from 78 to 79 for regular gasoline and from 86 to 87 for premium gasoline. Specification D439 revisions reflect these changes.

Sulfur in Fuel Gases to Be Checked by New Method

Recommendations of its Committee D-3 on Gaseous Fuels for new Tentative Methods for Determination of Total Sulfur in Fuel Gases (D 1072) were recently accepted by the American Society for Testing Materials Administrative Committee on Standards.

The new method is intended for determination of sulfur when present in concentration between 1.0 and 30 grains of sulfur per 100 cf and is applicable to natural gases, manufactured gases, and mixed gases such as are distributed by gas utility companies.

The committee's recommendations for revisions of the Tentative Methods for Measurement of Gaseous Fuel Samples (D 1071) were also accepted. Since their original publication, a number of suggestions have been offered for modification of the provisions dealing with meter calibration in order to clarify them further. The present revisions were developed after study and experiment along these lines.

Air Pollution Symposium Adds Third Day to Program

The Third National Air Pollution Symposium, originally announced for April 18 and 19 at Pasadena, Calif., will run three days, April 18 through 20.

The meeting, to be held at the Huntington-Sheraton Hotel, is expected to draw participation from international scientific and industrial interests in air pollution.

Co-sponsoring the symposium with Stanford Research Institute are California In-

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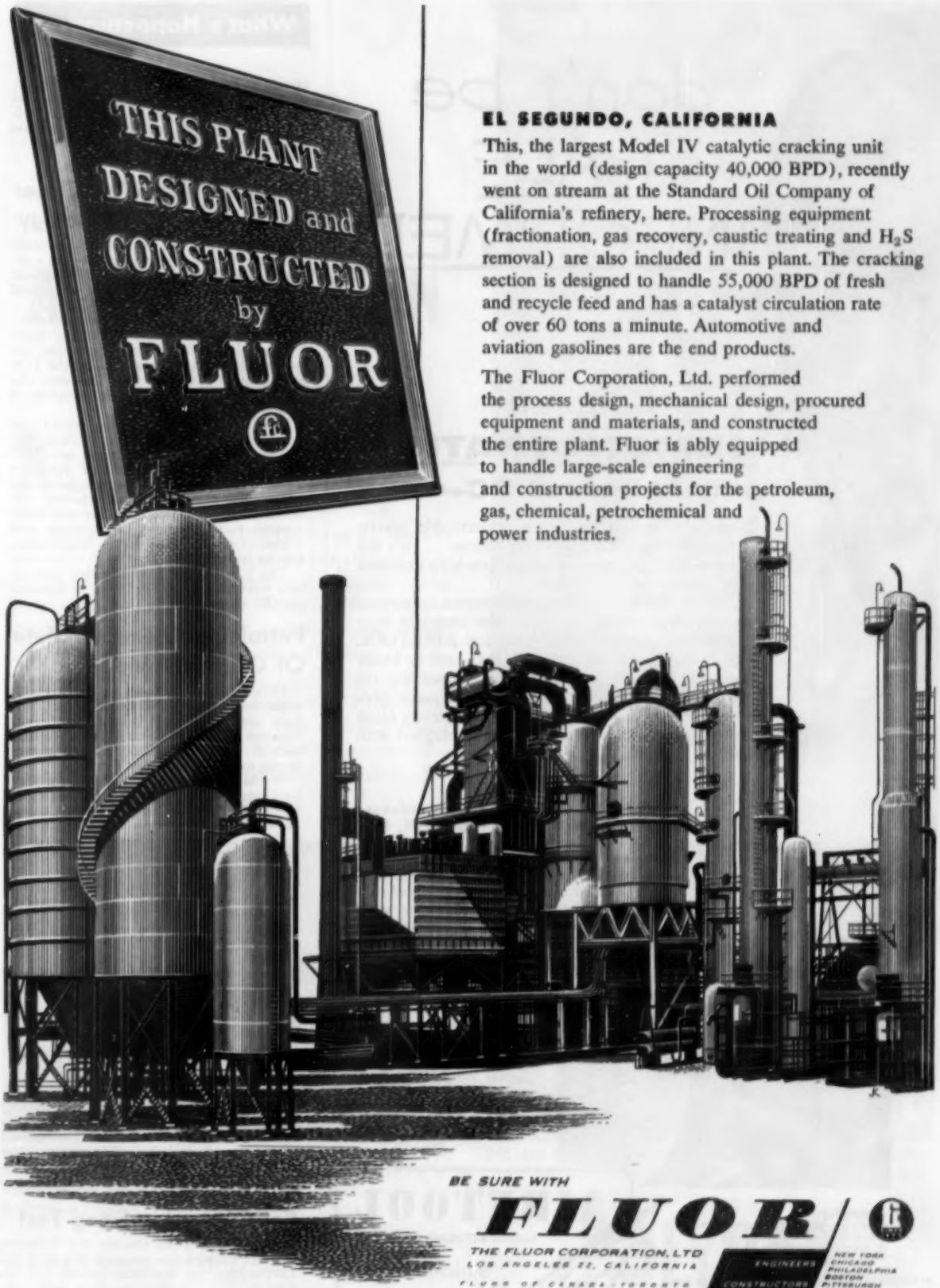

EL SEGUNDO, CALIFORNIA

This, the largest Model IV catalytic cracking unit in the world (design capacity 40,000 BPD), recently went on stream at the Standard Oil Company of California's refinery, here. Processing equipment (fractionation, gas recovery, caustic treating and H_2S removal) are also included in this plant. The cracking section is designed to handle 55,000 BPD of fresh and recycle feed and has a catalyst circulation rate of over 60 tons a minute. Automotive and aviation gasolines are the end products.

The Fluor Corporation, Ltd. performed the process design, mechanical design, procured equipment and materials, and constructed the entire plant. Fluor is ably equipped to handle large-scale engineering and construction projects for the petroleum, gas, chemical, petrochemical and power industries.

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REPRESENTATIVES in principal cities of U.S.A., Canada, Mexico, South America, England, Japan
BRANCH OFFICES: New York, Chicago Philadelphia, Tulsa, Houston, Baton Rouge

What's Happening. . .

stitute of Technology, University of Southern California, University of California at Los Angeles, Southern California Air Pollution Foundation and the Air Pollution Control Association of Pittsburgh, Pa.

NBS Moves to Work Closer With Nation's Technology

Twelve technical area advisory committees have been established to provide a direct, continuing link between the National Bureau of Standards and the organized science and technology of the U.S.

The setting up of the committees resulted from a comprehensive survey made by the Ad Hoc Evaluation Committee, appointed almost two years ago by the U.S. Secretary of Commerce to evaluate the National Bureau of Standards' program in relation to national needs.

The Evaluation Committee survey, reported in October of last year, held that the Bureau's statutory functions were well conceived and its operations generally sound. At the same time, it recognized the desirability of some means whereby the needs of the nation's scientific and engineering societies could be expressed and transmitted to the Bureau for implementation in its program.

The 12 technical area advisory committees were set up during 1954 to transmit to NBS those needs.

Petroleum Chemicals Slate Of Officers Announced

Officers and directors of the recently organized Petroleum Chemicals, Inc., have been announced jointly by Cities Service Company and Continental Oil Company, each of whom owns a 50 percent interest in the new petrochemical firm.

W. Alton Jones, New York, Cities Service Company, will serve as chairman of the board. L. F. McCollum, Houston, Conoco, has been elected president.

Other officers announced are: A. P. Frame, New York, Cities Service, vice president; Harold G. Osborn, Ponca City, Okla., Conoco, vice president; B. R. Johnston, New York, Cities Service, secretary and treasurer; Keith Blinn, Houston, Conoco, assistant secretary, and C. B. Wedum, New York, Cities Service, assistant secretary.

Jones, McCollum, Frame and Osborn have been elected to the board of directors. Other directors: E. F. Battson, New York, Conoco; Charles A. Perlitz, Jr., L. C. Peters and Dr. John E. Kircher, all of Conoco, Houston, and B. S. Watson, G. L. Mateer, H. L. O'Brien and W. H. Price, all of Cities Service, New York.

Petroleum Chemicals, Inc., recently offered to purchase the government-owned butadiene plant at Lake Charles from the Rubber Facilities Disposal Commission. The sale, along with 27 similar sales throughout the country, is subject to approval by Congress.

Cat Okayed in Smog Test

The Los Angeles County Air Pollution Control District has granted Richfield Oil Corporation an operating permit for the latter's new catalytic cracking unit. The permit had been previously denied.

The new permit enables the plant to

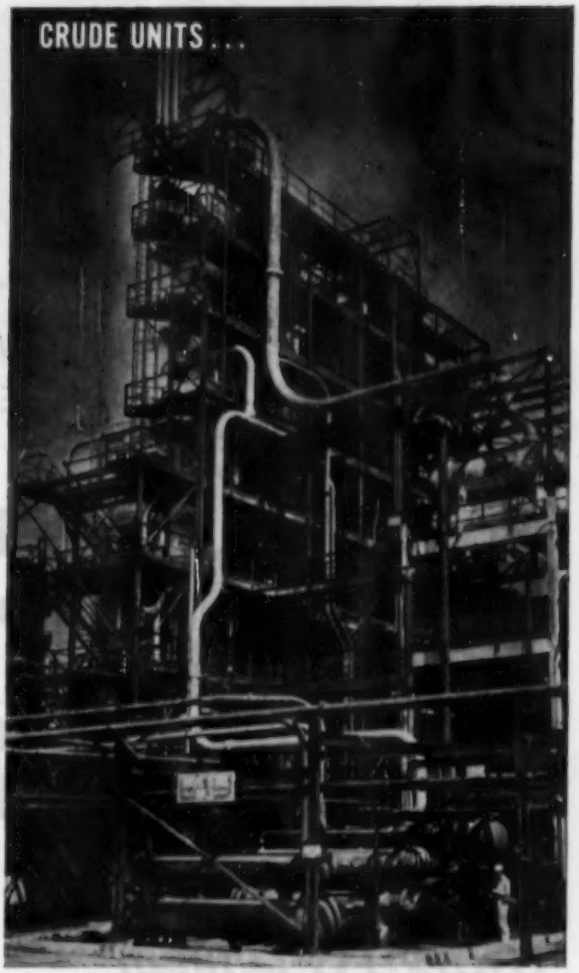
POLYRAD CONTROLS ACID CORROSION

all around the refinery

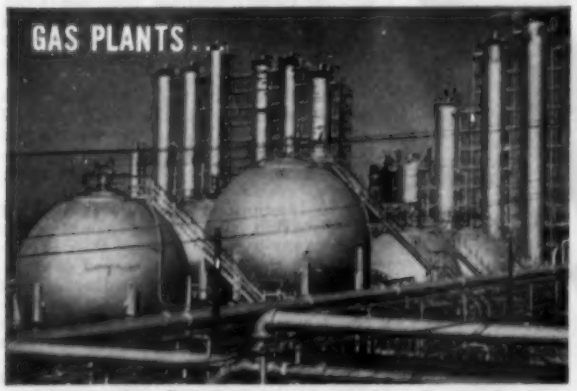
From crude units to gas plant areas, Hercules Polyrad controls corrosion, helps maintain throughput, increases heat transfer, reduces metal loss, and cuts down time for maintenance.

A filming amine inhibitor, Polyrad forms a protective molecular film that safeguards refinery equipment from hydrogen-ion attack by organic and inorganic acids. Developed through Hercules research, Polyrad was specifically designed to control corrosion at low pH and it is highly effective over the entire pH range encountered in refinery operations.

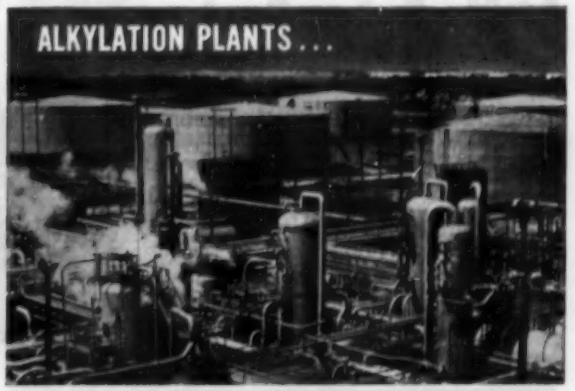
Polyrad is quickly available from stocks located strategically throughout the nation. One of our technical representatives will be glad to work with you in evaluating Polyrad under your operating conditions. For additional data, write Hercules.



A PLUS FEATURE of Polyrad through the refinery is its detergent action which loosens iron sulfide and other scales so that they can be removed in the fluid stream.



CUTS DOWNTIME—By helping to maintain throughput and reducing metal loss, Polyrad keeps down time for maintenance to a minimum any place in the refinery where acidic corrosion or fouling is a problem.



POLYRAD PROTECTS many types of refinery equipment from hydrogen-ion attack. It is useful in condensers, distillation columns, re-boilers, and heat exchangers.

Naval Stores Department

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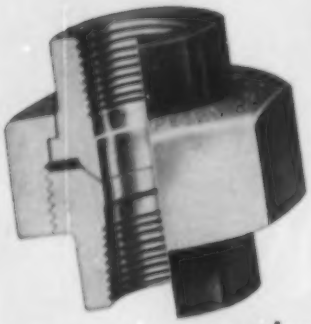

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STUDS • THREADED BARS • STILL SCREWS • STAINLESS STUDS AND NUTS

What's Happening. . .

continue operation which has been continuous since completion of the unit last fall. A spokesman for the Control District said new operating tests made January 10 showed electrostatic precipitators had kept dust emissions to 24.7 pounds per hour, well below the 40-pound-per-hour limit.

Du Pont Survey Shows Rise in Octane Ratings

Average research octane ratings of premium and regular gasolines continue to rise, according to the January Motor Gasoline Survey released by Du Pont's Petroleum Chemicals divsion.

The quarterly survey covering 44 cities in the U. S. and six in Canada shows octane ratings on premium gasolines up in 38 cities, down in eight and unchanged in four last month as compared to October. Regular octane ratings were up in 31 cities, down in 14 and unchanged in five.

Baltimore scored the highest octane rating in premium gasoline with 95.5. Dallas, Fort Worth and Little Rock led the October survey with 95.3 ratings.

Scott and Vernon Will Get 1955 NACE Awards

Gordon N. Scott, consulting engineer in Los Angeles, and W. H. J. Vernon of England have been selected to receive the 1955 National Association of Corrosion Engineers awards. The awards will be made at the banquet to be held during the NACE 11th Annual Conference and Exposition in Chicago, March 7-11.

Dr. Scott, who has been in corrosion work more than 20 years, will receive the Frank Newman Speller Award for achievements in corrosion engineering.

Vernon will receive the Willis Rodney Whitney Award for achievements in the field of corrosion science.

NPC Report Recommends Closing Shale Oil Plant

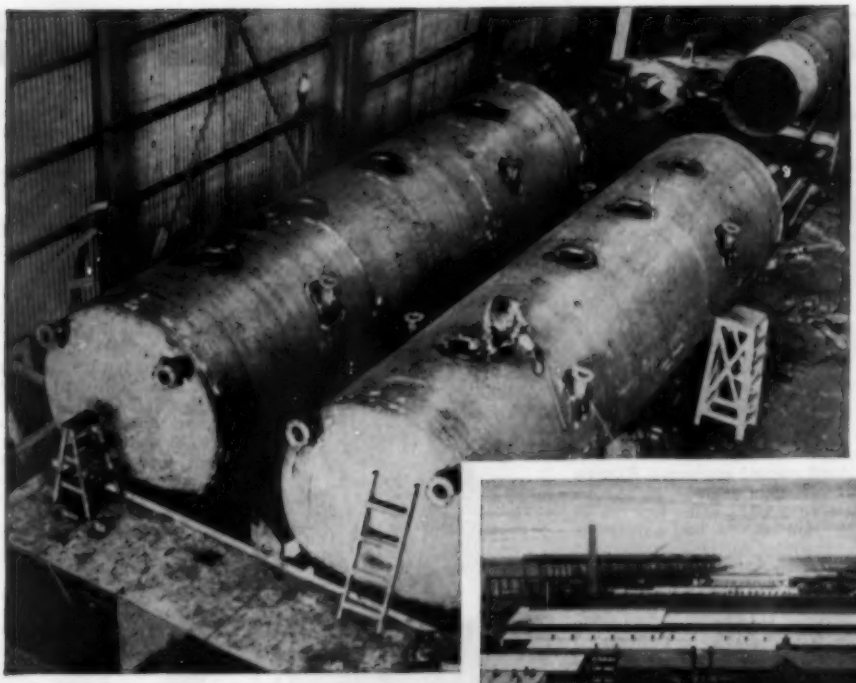
A recommendation by the National Petroleum Council that the government put its oil shale plant at Rifle, Colo., on a stand-by basis is expected to assure that the plant will be closed at the end of the present fiscal year.

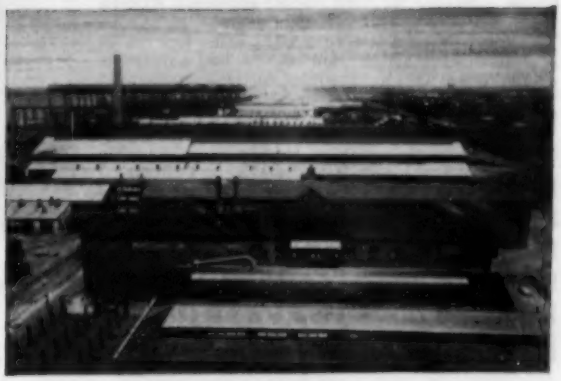
Funds for continuation of the plant were not included in the President's annual budget message to Congress; nor did the budget request include provision for continuation of oil shale research at Laramie, Wyo.

The Interior Department was reported to have asked for the same amount as last year for the Rifle plant (more than $1 million), but the request was turned down by the Bureau of the Budget, pending a report from a special Petroleum Council committee. A special survey team for the Bureau of Mines earlier had recommended that work at the Rifle plant be discontinued.

In its committee report, the council praised experimental work by the Bureau of Mines, but pointed out that private companies are now engaged in oil shale development, saying that further government efforts along that line are no longer needed. Union Oil Company of California and Sinclair Refining Company are building oil shale facilties.

The President's proposed budget did include, however, $817,600 for coal-to-gas hydrogenation research at Bruceton, Pa., and $72,600 for gas synthesis research at





A Mile of Shops — Each shop is devoted to a special type of heavy production. Included are complete Machine Shops, casting, forging and other facilities which offer all of the advantages of the execution of the complete job.

A half mile of pressure vessels

These are two of seventy — over ½ mile — of 38½-foot vacuum tank casings built to meet the quality requirements of a well-known processor.

The buyer also benefits from many savings made possible by Newport News extensive heavy fabrication equipment and the sixty years experience in using it.

Do you plan installations of heavy production equipment? You can command the services of Newport News for weldments of corrosion-resistant, alloy and clad metals in almost any size or shape, plus the required engineering background and complete welding and stress-relieving skills.

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To save time for hard-pressed engineers, Eastern is happy to offer a complete engineering service for helping you select the right units. Just fiill in a data sheet, supplied on request, and a mixer or pump will be recommended for your application that provides trouble-free performance, with weight, size, power, and *costs* kept to a minimum.

Write for group of catalogs and data sheets that covers the complete Eastern lines: Portable Mixers, Top & Side-Entering Mixers; Centrifugal Pumps, Positive Pressure Pumps, and Midget Pumps. Request Catalog Series 20.

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A complete reference catalog on Dura Seal—the engineered mechanical seal that rotates with the shaft. Amply illustrated . . . specific applications . . . installation data. A fact book of real value to designers, operators and maintenance departments.

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KALAMAZOO, MICHIGAN

What's Happening. . .

the same place. The Interior Department's Synthetic Fuels division seeks $1,585,000 for coal gasification work at Morgantown, W. Va. and $1,250,000 for petroleum and natural gas research at Bartlesville, Okla., Laramie, Morgantown and San Francisco.

Congress Receives Folio Of Rubber Plant Sales

Congress has received the Rubber Producing Facilities Disposal Commission's recommendations for selling the government's synthetic rubber monopoly to private industry. The proposed sales are expected to bring a gross return of more than $401 million to the government.

Anti-trust clearance was given for the folio of contracts after the Justice Department looked into proposed sales of the government's two butyl innertube plants to affiliates of Standard Oil Company (New Jersey).

Esso Standard Oil Company and Humble Oil and Refining Company entered high bids for butyl plants at Baton Rouge, La., and Baytown, Texas, respectively. Attorney General Herbert Brownell, Jr. approved the sales after Esso agreed to sell the Baton Rouge plant under certain conditions, and Jersey Standard offered patent licenses and advice to other members of the industry.

Approval of another sale came after a careful study of a combine of Goodrich-Gulf Corporation and U. S. Rubber-Texaco which bid in for the butadiene plant at Port Neches, Texas. The bidders assured the Justice Department they would acquire raw materials separately and market butadiene independently.

The disposal commission has received bids for 24 of the 27 government-owned plants put up for sale. Oil companies and their affiliates are parties to purchase 13 of the plants.

Sunray, Mid-Continent Close to Formal Merger

A plan for the merger of Mid-Continent Petroleum Corporation and Sunray Oil Corporation has been agreed to in principle by the boards of the two companies.

Under the merger plan the $458 million corporation resulting would be called Sunray Mid-Continent Oil Company.

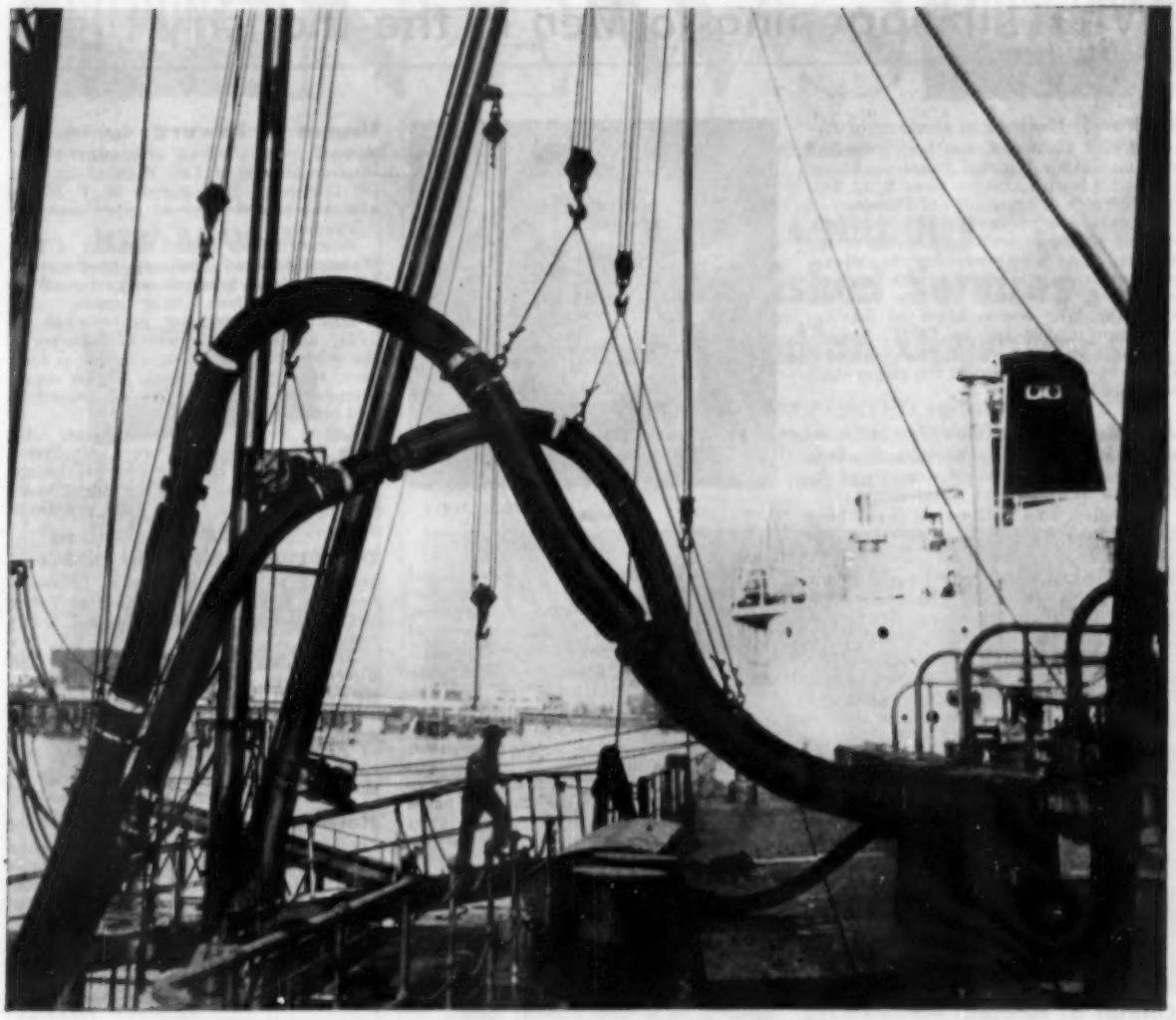
The plan calls for the organizing of a new company, D-X Oil Company, as a wholly owned subsidiary to carry on the refining, crude oil, pipe line and marketing activities of Sunray Mid-Continent Oil Company. Sunray's present refining, pipe line and sales activities would be incorporated into the new D-X Oil Company.

All operating personnel of the two companies will be taken into the new Sunray Mid-Continent organization which will have a daily refining capacity of 100,000 barrels, with catalytic cracking facilities at Oklahoma refineries.

C. H. Wright, chairman of Sunray, will be chairman and chief executive officer of Sunray Mid-Continent. R. W. McDowell, president of Mid-Continent, will be, vice chairman, and also president of D-X Oil. W. C. Whaley, president of Sunray, will be president of Sunray Mid-Continent. Each will be a director of Sunray Mid-Continent. Other directors have not yet been announced.

A formal agreement of merger by the boards of the two companies must then be submitted to shareholders.

For more data on advertised products, use Readers' Service Cards, last page.



No Collapse, No Kink, No Crush

It takes a tough hose to load or unload petroleum products from barges or tankers . . . but Ebonite-Skookum Oil Suction and Discharge hoses do the work with a minimum of friction loss.

The heavy gauge tube is made of a special oil-resistant compound. Next to the tube there's a single ply breaker strip, frictioned for strong adhesion between tube and reinforcement. Next come multiple plies of close woven fabric . . . seven to twelve of them . . . surrounding a helix of high tensile, spring steel wire.

This rugged construction eliminates expansion under pressure, collapse under suction, and resists kinking and crushing. This hose stands up under severest duty. Ends are reinforced to prevent bending or breaking at high-pressure, built-in steel nipples. Available in I. D. sizes 3″ to 12″; up to 50-foot lengths.

We also manufacture a complete line of industrial rubber products: belting, hose, packing and moulded rubber for every need. *Through your Quaker and Quaker Pioneer distributor* our research and engineering services are available to help you solve any industrial rubber problem. *Write for name of nearest distributor.*

QUAKER RUBBER CORPORATION
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San Francisco 7, California

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening *to Men* in the Industry . . .

Walter S. Hallanan, president of Plymouth Oil Company, has been reelected chairman of the National Petroleum Council for his tenth successive term. R. G. Follis, chairman of Standard Oil Company of California, was reelected vice chairman. Present chairman and membership of the two standing committees—Agenda and Appointment—were reelected with one exception, L. S. Wescoat, of The Pure Oil Company, who was replaced on the Appointment Committee by D. T. Staples, president of Tide Water Associated Oil Company. James V. Brown was reappointed secretary treasurer.

J. B. Macauley, director of technical coordination for Ethyl Corporation, has been appointed deputy assistant secretary of defense for research and development.

Macauley, who will be on leave from Ethyl during his year of tenure with the government, succeeds **Dr. Daniel P. Barnard,** research coordinator of the Standard Oil Company (Indiana). Dr. Barnard is expected to return to his company within the next few months.

Before joining Ethyl, as director of engineering research at the Detroit laboratories in 1945, Macauley was associated with Pratt and Whitney as director applied research. He also served with Chrysler Corporation, American Brake Shoe Company, Lincoln Motor Company and Packard Motor Company.

Milton S. Beringer, chairman of British American Oil Company, Ltd., has been named president in addition to his present post following the resignation of Ole Berg, Jr., as president and director. Named executive vice president was J. Gerald Godsoe, who has been vice president and director.

Charles S. Mitchell, who has been associated with Cities Service Company for the last 25 years, has been appointed manager of all transportation facilities of the company. Since 1950, he has been manager of the Crude Oil Supply and Transportation division of Cities Service Oil Company (Del.).

Gerald F. Bassler has been appointed director of training for Continental Oil Company's Manufacturing department, with headquarters in Houston, succeeding M. L. Cobb, who was recently promoted to superintendent of Conoco's refinery at Ponca City, Okla. Since 1953 Bassler has been management development supervisor for The Murray Corporation, Detroit automotive parts manufacturers. Previously he served five years as senior training supervisor for Creole Petroleum Corporation in Venezuela.

Bassler

Simpson

Thomas P. Simpson has been elected vice president and director of manufacturing at General Petroleum Corporation, another forward step in an advancement that really got started 30 years ago.

Soon after his graduation from California Institute of Technology in 1924, with a B.S. degree in chemical engineering, Simpson joined General Petroleum as a chemical engineer. Following some minor fluctuations in his career, in 1935 he was transferred to Socony-Vacuum Oil Company, Inc., of which General Petroleum is the western affiliate. He began as chief development engineer of the Socony-Vacuum Laboratories, advancing in 1947 to director, Research and Development department, of Socony-Vacuum with headquarters at Paulsboro, N. J.

Upon his return to General Petroleum in August, 1953, he became assistant director of manufacturing, the post from which he was recently promoted. In his new assignment he succeeds Gale L. Adams, retired.

A better than average golfer (who shoots in the middle 70s), he has proved himself equally adept with the pen, having written some 20 scientific articles dealing with catalytic cracking and petroleum processing in general.

A native of Southern California, he is affiliated with several technical organizations, among which are ACS, AIChE, API and the American Institute for the Advancement of Science.

Thomas O. Edwards has been appointed manufacturing manager of the Western division of Tide Water Associated Oil Company. He succeeds W. P. Hugo, who has retired after 41 years of service with the company. Edwards has been serving as general manager of the company's refinery at Associated, Calif.

Franklin C. MacKrell, a vice president of Stone & Webster Engineering Corporation, has been appointed district manager in charge of the corporation's Chicago office. His appointment follows the recent retirement of Louis H. G. Bouscaren, who had been Chicago district manager for 31 years. Bouscaren had been with the company more than 50 years.

Thomas O. Edwards has been appointed manufacturing manager of the Western division of Tide Water Associated Oil Company. He succeeds W. P. Hugo, who has retired after 41 years with the company.

Promoted from general manager of Tide Water Associated's refinery northeast of San Francisco, Edwards was replaced by his former assistant, Oscar Larson.

Edwards joined the organization in 1921. Before rising to general manager of the refnery, he served successively as foreman, tract superintendent, process superintendent, assistant general superintendent and general superintendent.

Larson began his refnery career with Tide Water Associated as a pipefitter's helper in 1923. He rose through the operating ranks to area superintendent, process superintendent and in 1941 was made assistant general manager.

David L. Arm, dean of the school of engineering at the University of Delaware, has been appointed manager of the Industrial department of the National Safety Council.

Before becoming dean at Delaware, Arm directed the Mechanical Engineering department at Iowa State College, taught engineering and served as director of personnel at Purdue University, and taught at Lafayett College. He has served as a consultant for several industrial organizations, as well as for the Navy.

Howard J. Pixley has been named chemical operations engineer at Stanolind Oil and Gas Company's chemical plant in Brownsville, Texas. Pixley has been working in the company's general offices at Tulsa for the past several years.

James N. Gorringe, former coordinator of executive development for Esso Standard Oil Company, has been named employe relations manager for the company.

Gorringe

Gorringe, who has headed employe relations at the company's Baltimore, Bayway and Bayonne refineries, also served as assistant process superintendent at the Bayonne refinery. After World War II, in which he served as a Navy personnel officer, Gorringe returned to the company and, following refinery posts, transferred to New York to head the Executive Development group.

George D. McClelland and **Frank R. Grant** have joined the engineering staff of George Armistead. Previously employed with Magnolia Petroleum Company and Hunt Oil Company, McClelland will be in charge of mechanical engineering at the firm's headquarters in Washington, D. C.

Grant, formerly associated with Lion Oil Company and Consumers Cooperative Association, has also served in two gov-

PETROLEUM CHEMICALS DIVISION
NEWS

February ★ One of a Series of Interest to the Petroleum Industry ★ 1955

NEW BOOKLET

to help you explain surface ignition to non-technical people

Outside of a small group of specialized engineers, few people understand surface ignition.

What causes it? How does it manifest itself? What are its harmful effects? And what can you do to overcome the problem?

The chances are you are frequently asked these questions, by outsiders and executives of your own company. But accurate, clear-cut, easy-to-understand answers are often hard to come by.

So to help you promote a better and wider understanding of surface ignition, and the problems surrounding it, Du Pont has prepared an eight-page booklet entitled "Combustion and Surface Ignition." It is profusely illustrated in full color. And it explains quickly and understandably the phenomenon of surface ignition and the technical terms used to describe it.

The booklet is now available to fuel engineers for limited distribution. Any of our regional offices will be glad to supply you with a sample copy and information on obtaining additional copies.

Unique Dust-Injection Engine for Studying Surface Ignition

In order to study the erratic process of surface ignition under controlled conditions, engineers at the Du Pont Petroleum Laboratory have developed a novel technique, called the "aspirated deposit surface ignition test."

In this modified C.O.T. engine with electronic counter, engineers can create controlled surface ignition by introducing a small amount of powdered combustion chamber deposit.

The technique uses a single-cylinder engine, modified to permit the introduction of a small amount of combustion chamber deposit into the intake port. This *dust-injection* engine uses a fuel susceptible to surface ignition, containing benzene or diisobutylene. To isolate chemical reactions associated with surface ignition, the engine operates under typical non-knocking conditions.

Pin-pointing ping

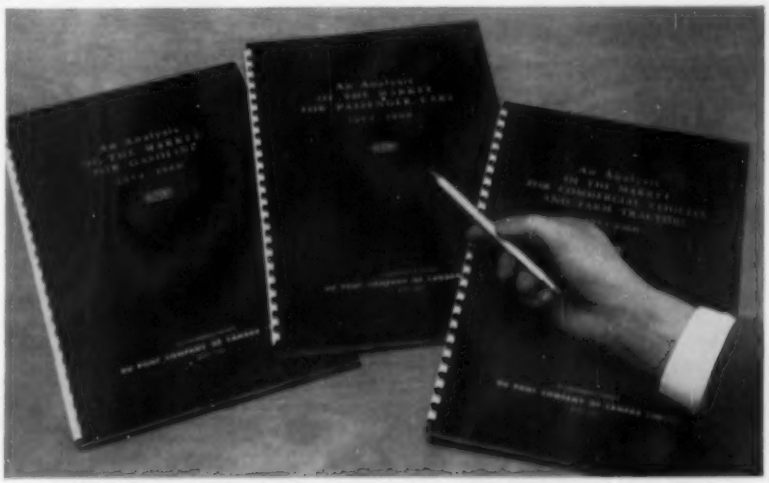
The number of surface ignitions caused by the introduction of the combustion chamber "dust" is taken as the measure of surface ignition harm of deposits.

Surface ignition is detected by an internal type of pickup, mounted in the engine cylinder. The number of surface ignitions is counted by a four-decade counting unit actuated by a signal from the pickup.

Findings from this unique test method reveal the relationship between the composition of combustion chamber deposits and their contribution to surface ignition.

A New Company With Established Services For Your Canadian Operations

DU PONT COMPANY OF CANADA LIMITED, and its Petroleum Chemicals Division, offer a wide range of marketing, technical and safety services to all oil companies operating north of the border. If you are considering expansion in or to Canada, these services can have an important bearing on your plans.



THESE THREE recently completed forecasts deal with the Canadian market exclusively. They cover gasoline, passenger cars, commercial vehicles and farm tractors—for the period from 1954 to 1960. They are offered as an oil industry service by Du Pont of Canada.

Suppose, for example, you want to build a new refinery in Alberta. You want to employ local workers wherever possible. But training local blending plant personnel in the safe handling of tetraethyl lead presents a real problem. To transport a special training crew from the States is likely to prove difficult and costly.

Here is a typical case where a Du Pont of Canada representative can be extreme-

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED *Du Pont of Canada*

ly valuable to you. And in addition to helping with employee training and safety projects, the Canadian representatives are prepared to offer many specialized services in connection with the design, site selection, construction, and operation of your blending plant.

Who, what, where? . . .

Du Pont of Canada is a separate, individual company . . . one of two companies recently formed out of the former Canadian Industries Limited.

Its Petroleum Chemicals Division has its headquarters in Toronto, with branch offices in Montreal and Calgary. It handles the complete Du Pont line of lube oil, fuel oil and grease additives, as well as gasoline dyes, antioxidants, Metal Deactivator and tetraethyl lead.

The Canadian sales-service representatives have had the same extensive technical training and oil industry experience as their stateside colleagues. And the services they offer are exactly parallel, too.

Developing a new market

With all forecasts pointing to a tremendous expansion in the Canadian economy during the next few decades, it can be expected that petroleum products marketing, as well as production and refining, will play an increasingly important role in Canadian Oil Industry activities.

To help you make the most of this growth potential, a wide range of movies, booklets, special presentations and other sales promotion aids are available to Canadian marketers through Du Pont of Canada. And this service also includes such industry-wide public relations programs as the well-known Du Pont "Magic Barrel."

Laboratory services, too

Although the five Du Pont Petroleum Chemicals Division regional laboratories are located in the United States, the services of these unique laboratories are available to all Canadian oil companies.

What's more, the Petroleum Chemicals Division of Du Pont of Canada is backed up by the basic research activities of the Du Pont Petroleum Laboratory and Experimental Station in Wilmington.

So if you are now operating in Cana-

Continued—bottom of next column

da or plan to in the future, be sure to keep in touch with one of the Du Pont of Canada Petroleum Chemicals Division representatives. He can be a very helpful man to know.

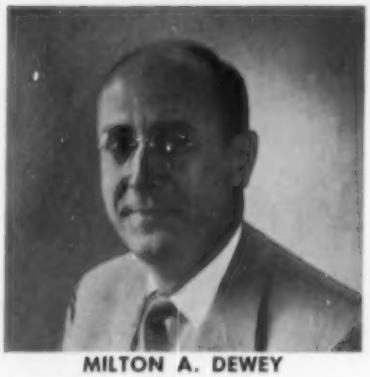
CANADIAN MANAGER

MILTON A. DEWEY is manager of the Petroleum Chemicals Division, Du Pont Company of Canada Limited.

After graduating from the University of Illinois with a B.S. degree in Chemical Engineering, he joined the Mid-Continent Petroleum Corporation in Tulsa, Oklahoma as a refinery engineer. Mr. Dewey left Mid-Continent to accept a research fellowship at Pennsylvania State College—working in the Petroleum Refining Laboratory, sponsored by the Pennsylvania Grade Crude Oil Association.

He then joined the staff of the Gulf Research Corporation in Pittsburgh and later became head of this company's Analytical Laboratory, in charge of research on turbine and electrical oil additives.

Mr. Dewey came to Du Pont in 1937. One of his first jobs at Du Pont was as liaison between the oil company research laboratories and various Du Pont laboratories. In this capacity, product development work was one of his chief responsibilities.



MILTON A. DEWEY

In 1950, he was transferred to Canadian Industries Limited, in charge of petroleum chemicals sales. He continued in this assignment until Du Pont of Canada was formed last July, at which time he was appointed to his present position.

Sales Opportunity for Lube Oils With Low-Duty Detergents

For 48% of American passenger cars, the average trip is less than 4 miles. For 75%, it is less than 10 miles. For only 15% it is 16 miles or over. And for all city busses, taxis and delivery trucks, more than 90% of their total operation is local stop-and-go traffic.

And these low-power, low-temperature operating conditions lead to excessive build-ups of engine sludge.

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LOS ANGELES, CALIF.—612 So. Flower St. Phone MAdison 5-1691

IN CANADA: Du Pont Company of Canada Limited—Petroleum Chemicals Division, 80 Richmond Street West, Toronto 1, Ontario
OTHER COUNTRIES: Petroleum Chemicals Export—Nemours Bldg., 6539—Wilmington 98, Del.

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A-6712

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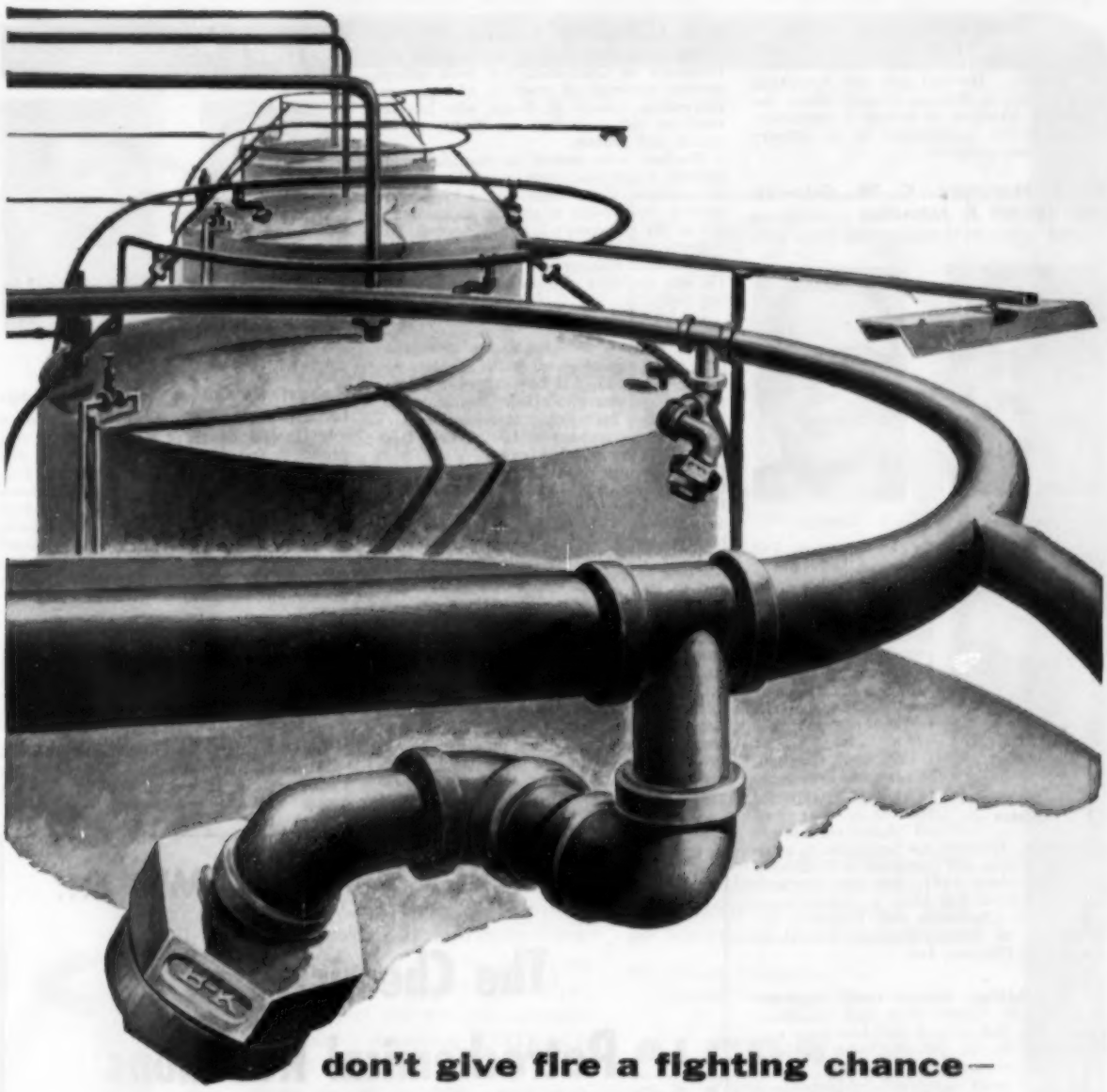

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ernment agencies: Petroleum Administration for War during World War II and more recently, Petroleum Administration for Defense. He will join the Armistead firm's office in Athens, Greece, where the company is acting as technical consultant to the Greek government in its refinery construction program.

H. J. Morsman, C. W. Gilmore and **Robert J. Johnston** have been named to top-level engineering posts with

Morsman

Gilmore

Johnston

Great Northern Oil Company. Morsman, Curacao, Netherlands, was named process suintendent; Gilmore, Rodeo, Calif., senior process engineer, and Johnston, St. Paul, Minn., process engineer. For the past 18 years Morsman has been with Royal Dutch Shell, Curacao, West Indies, as assistant refinery superintendent in charge of all phases of refinery operations. Gilmore has been process engineer for Union Oil Company of California at Rodeo since 1947. For the past two years, Johnston has been a process engineer in the Operating and Technical departments of Socony-Vacuum Oil Company, East Chicago, Ind.

E. J. Schiffer, general traffic manager of Gulf Oil Corporation and subsidiary companies, has retired and has been succeeded by W. M. Johnson, who has been serving as assistant traffic manager. A veteran of 39 years of service, Schiffer joined Gulf in 1915 as a messenger.

Wallace G. Alexson has joined the staff of the Contract Sales department of The M. W. Kellogg Company, a firm engaged in designing and building chemical plants and oil refineries.

Alexson

Associated with Esso Standard Oil Company for nine years as a chemical engineer in charge of crude evaluation, Alexson also was on loan to the government two years serving in the Office of Rubber Reserve in Washington.

A. P. Frame has been named to the Cities Service Company board to be in charge of manufacturing, research and petrochemical development.

Fred L. Hartley, former manager of commercial development for Union Oil Company of California, has been named general manager of research and process, succeeding Claude E. Swift, who has retired as vice president in charge of research and process.

Hartley, who served as manufacturing process supervisor, was named manager of commercial development in 1953 after serving three years as general superintendent at the company's Los Angeles refinery.

Swift joined the company in 1926 and was named manager of research in 1947. He was elected a vice president the following year.

J. B. Willis, assistant to the vice president in charge of research for Sinclair Refining Company, has been appointed chief process engineer of Sinclair Chemicals Inc.

Beginning his refining career in Sinclair's Research department in 1940, Willis later served in the refining company's Process Design division and in 1950 was transferred to the Technical department of Sinclair Rubber, Inc. He became administrative assistant at the firm's rubber plant in Houston in 1953 and last year, returned to the refining organization as assistant to the vice president for research.

Jack R. Bruner, former chemical engineer with George Armistead and Company, has joined the refining staff of Hancock Oil Company. He will serve at the company's refinery at Long Beach, Calif.

Previously connected with New Mexico Asphalt and Refining Company and Southwestern Engineering Company, Bruner was project manager for the Armistead organization during a recent construction program for Hancock.

What's Happening. . .

Haglund

Cutler

Robert R. Cutler and **C. J. Haglund** have been appointed vice president and Central district manager, and vice president and manager of the Western district office, respectively, of The H. K. Ferguson Company. Cutler, who has been acting manager of the company's Central district since last October, joined Ferguson in 1949. For the last two years, Haglund has managed Ferguson's Alaska district. Previously he was vice prresident of Morrison Knudsen Company.

George M. Jones and **Edwin Hill** have been appointed as assistant project engineers in Sun Oil Company's engineering division of the manufacturing department.

Jones, formerly an engineering assistant with the company, has been assigned to the electrical and instrumentation project group. Hill, also a former engineering as-

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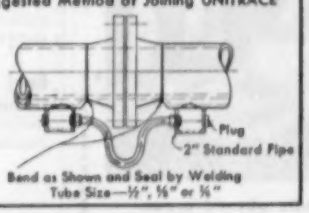

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What's Happening. . .

assistant, will work with one of the general project engineering groups.

Ouding

John Ouding has been promoted to manager of manufacturing at Wilshire Oil Company, Inc. Ouding joined Wilshire in 1923 as a refinery foreman. Advancing through various supervisory positions, he was appointed refinery superintendent in 1952, the position he held prior to his new appointment. In his new assignment he will be in direct charge of all refinery operations.

Quentin Benedict, formerly with Deep Oil Corporation, has become refinery superintendent of the Vickers Petroleum Company, Inc., refinery at Potwin, Kan. At the same time, **T. Ben Arnold,** formerly refinery superintendent, has become refinery manager. His promotion to the newly created post was part of a staff expansion in the Refinery division of the company.

Earl Noblet, employed with American Cyanamid Company since 1949, has joined the market development department of Sinclair Chemicals Inc.

Dr. Cedomir M. Sliepcevich, until recently a member of the chemical engineering staff at the University of Michigan, has taken over as chairman of the school of chemical engineering at the University of Oklahoma, succeeding Dr. R. L. Huntington, who has been relieved of administrative duties to devote more time to research.

Sliepcevich

Dr. Sliepcevich, consultant to a number of oil and chemical companies, joins the Oklahoma faculty with full professorial rank. Dr. Huntington will continue as a member of the school's chemical engineering staff.

A. H. Sus, for the past two and a half years assistant to the president of Sinclair Refining Company, has retired after almost 35 years of service. He joined the Sinclair organization in 1920 as division manager in charge of Michigan operations with headquarters in Detroit.

M. T. Miller, long associated with Standard Oil Company of California's production activities, is the company's new assistant to the vice president in charge of government relations and conservation. He replaces S. Z. Natcher, who has been assigned to London for the company.

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Heinemann—

Continued from page 91

Chem. in 1946 are correct but that there are a number of errors in the calculation of the derived values. These errors have never been noticed before, either by the reviewers for *Ind. and Eng. Chem.* or by the numerous people who have talked to us about these data in the past eight years. It is, of course, unfortunate that these calculation errors should have occurred and that they have been reprinted in the PETROLEUM REFINER article. One can only hope that since the basic data are correct, people will be able to check this, just as Dr. Glass has done.

There is a printing error for the bulk density of Fuller's Earth at 400° in the original publication. This was caught before reprinting it in PETROLEUM REFINER and corrected, for which reason the two publications do not agree. In this case, however, the values published in PETROLEUM REFINER for both basic and derived data are correct.

Heinz Heinemann

213 Dickinson Ave.,
Swarthmore, Pa.

Densities, Surface and Pore Properties of Adsorbents and Catalysts

(See letter, page 89)

Adsorbent	Orig. Publication Reference No.	Calcination or Activation Temp. °F.	D_B Bulk Density		D_A Hg Density		D_T He Density		VOID VOLUME					PORE VOLUME					Surface Area M^2/g
									Orig. Publ.		Pet. Ref.	S.W.G.		Orig. Publ.		Pet. Ref.	S.W.G.		
			Orig. Publ. g/cc.	Pet. Refiner g/cc.	Orig. Publ. g/cc.	Pet. Refiner g/cc.	Orig. Publ. g/cc.	Pet. Refiner g/cc.	(V. Basis) % Voids	cc./g	% Voids	(V. Basis) % Voids	cc./g	(V. Basis) % Voids	cc./g	% Pores	(V. Basis) % Pores	cc./g	
Activated Alumina	9, 16																		
Grade F-1		400	.88	.88	1.58	1.58	3.23	3.23	44	.50	44	44.3	.503	51	.32	51	51.1	.323	200
Grade H-151		400																	300-350
Bauxite	9																		
Arkansas		450	1.33	1.33	2.02	2.02	2.54	2.54	44[1]	.39[1]	44[1]	34.2	.257	20	.10	20	20.5	.101	27
		700	.97	.97	1.68	1.68	3.18	3.18	43	.34[1]	43	42.3	.436	64[1]	38[1]	64[1]	47.2	.281	236
		900	.95	.95	1.63	1.63	3.21	3.21	42	.44	42	41.7	.439	49	.30	49	49.2	.302	176
		1300	.94	.94	1.61	1.61	3.36	3.26[3]	42	.44	42	41.6	.443	52	.32	52	52.1	.324	151
South American		900	.96	.96	1.51	1.51	3.25	3.25	36	.38	36	36.4	.379	54	.36	54	53.5	.354	187
Silica Gel	6, 7, 9	400	.78	.78	1.32	1.32	2.12	2.12	41	.52	41	40.9	.524	38	.28	38	37.7	.286	602
Synthetic Silica-Alumina Gel	6, 7, 9																		
Fluid Catalyst		400	.....	.82	.....	1.38	.....	2.25	.....	.....	41	40.6	.495	.....	.....	39	38.7	.280	374
Pelleted Catalyst A		400	.64	.64	.962	.97[3]	2.37[3]	2.37[3]	.....	.....	34	33.5	.523	(59.6)	.620	58[3]	59.5	.619	372
Pelleted Catalyst B		400	1.00	1.00	1.558	1.56	2.369	2.37	.....	.....	36	35.8	.358	(35.5)	.228	34	34.2	.220	280
Bead Catalyst		400	.....	.79	1.137	1.14	2.380	2.38	.....	.....	30	30.5	.386	(52.0)	.457	52	52.2	.459	420
Fuller's Earth (attapulgite)	13, 8	400	.583	.56[3]	1.01	1.01	2.46	2.56[3]	42.3	.725	44[3]	42.3	.726	60.5[1]	.599[1]	60[1]	58.9	.583	126
		600	.546	.55	.97	.97	2.68	2.66[3]	43.7	.801		43.7	.800	63.8	.658		63.8	.658	124
		900	.578	.54[3]	.96	.96	2.66	2.66	39.8	.688	43[3]	39.8	.689	64.0	.667	64	63.9	.666	118
		1100	.534	.56[3]	.92	.92	2.69	2.69	42.0	.786	42	42.0	.787	65.9	.716	64[3]	65.8	.715	119
Bentonite		700	.....	.68	.....	1.140	.....	2.65	.....	.....	41	40.3	.593	.....	.....	57	57.0	.500	260
Acid Activated		900	.....	.67	.....	1.130	.....	2.66	.....	.....	41	40.7	.607	.....	.....	57	57.5	.509	236
		1300	.....	.67	.....	1.120	.....	2.56	.....	.....	41	40.2	.600	.....	.....	56	56.2	.502	208
Diatomaceous Earth	6, 7	400	.32	.32	.631	.63	2.265	2.27	.....	.....	49	49.3	1.541	(71.9)	1.14	44[3]	72.1	1.143	4
Activated Carbon	6, 7																		
Columbia Carbon		....	.42	.42	.754	.75	1.897	1.89[3]	.....	.....	44	44.3	1.055	(60.5)	.802	60	60.3	.800	1397
Darco Carbon		....	.36	.36	.732	.73	2.086	2.09	.....	.....	51	50.8	1.411	(65.0)	.888	66[3]	64.9	.887	560
Bone Char	2, 3	....	(.658)	.68[3]	(1.492)	.....	2.800	2.8	55.9	.....	47[3]	55.9	.850	46.7	.312	46[3]	46.7	.313	110

NOTE: Figures with reference numbers apparently in error of type indicated by:—
Superscript 1—Error in original publication.
Superscript 2—Error in calculation.
Superscript 3—Error where Pet. Refiner does not agree with original publication.

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Reviewing New Books . . .

Petrochemical Reactions

The Chemistry of Petrochemical Reactions, Lewis F. Hatch, Gulf Publishing Company, Houston, Texas, $4.50.

This volume is the only thorough and exhaustive treatise on the basic chemistry of reactions of those products and intermediates popularly classified as petrochemicals. As a complete contemporary study, this book is an immediate reference for anyone engaged in either the chemical or refining industry.

In addition to the technical data, commentaries on end use and markets of many significant chemicals are presented in such a manner as to make this book a practical working manual. The material in the book was originally published as an 18-part series in PETROLEUM REFINER. Revised to date by Dr. Hatch, these current and authoritative studies on petrochemicals are now indexed for easy reference by subjects or products.

Typical chapter headings include: Production and Reactions of Butadienes, Oxidation of Hydrocarbons, Nitration and Sulfonation of Paraffin and Aromatic Hydrocarbons, Alkylation with Olefins.

Engineering Basics

Elementary Chemical Engineering, by Max S. Peters, McGraw-Hill Book Company Inc., 330 West 42nd Street, New York 36, 307 pp., $6.

This book offers the essentials for a complete picture of chemical engineering, from basic theory to factors in planning a chemical plant layout. The author describes basic unit operations in chemical engineering, such as fluid flows, heat transfer, evaporation, absorption, extraction and drying, and then goes on to give a broader view of how these operations are put to work in the chemical-industrial field.

Material Selection

Materials for Product Development—1945, Clapp & Poliak, Inc., 341 Madison Avenue, New York 17, 160 pp., $7.50.

Hundreds of problems facing product designers in their selection of materials are discussed in this book, which contains the proceedings of the Basic Materials Conference held in Chicago last May.

Six basic problems were under consideration. These were "Materials of the Future"; "New Metal Forming Processes," such as precision castings, powder metallurgy, forging, extrusion and stamping; "Non-Metallic Materials," including plastics, carbon-graphite, ceramics and glass; "Joining," with emphasis on adhesives and adhesive bonding of metals and plastics; "Corrosion Protection," and "Materials Management," a description of how to set up and operate a materials department.

Clapp & Poliak, the publishers, produced the conference and the concurrent Basic Materials Exposition. This book is the second in a series.

Three from the U.S.

Instrumentation, U.S. Department of Commerce, Office of Technical Services, Room 6227, Washington 25, D.C. $2.

Electrical and Electronic Apparatus, U.S. Department of Commerce, Office of Technical Services, Room 6227, Washington 25, D.C. $4.

Chemical Products and Processes, U.S. Department of Commerce, Office of Technical Services, Room 6227, Washington 25, D.C. $3.

These three books were prepared by the Government Patents Board and published under the joint sponsorship of the U. S. Department of Commerce and Small Business Administration to encourage greater productive use of results of government-financed technical research.

Instrumentation includes 775 abstracts of government-owned patented inventions in the field of instrumentation and a list of the government agencies which administer the patents and issue royalty-free licenses under them or provide information on the availability and use of the inventions. The book is devoted entirely to the instrumentation industry and carries a brief description of each invention. The 775 listings are classified under eight subgroups, including laboratory and engineering instruments; instruments for measuring electrical quantities; and mechanical measuring and controlling instruments.

Electrical and Electronic Apparatus includes 1915 abstracts of government-owned patented inventions in the electrical and electronic field. The inventions are classified as to industrial use in the following groups: wiring devices and supplies; measuring instruments; particle accelerators; motors and generators; controls and switches; heating and welding apparatus; electric lamps; radio and related object locating and navigation apparatus; tubes; computing apparatus; telephone and telegraph equipment; batteries; x-ray apparatus, and miscellaneous products.

Chemical Products and Processes includes 1350 abstracts of government-owned patented inventions applicable to the chemical industry. The inventions are classified as to industrial use. Some of the classifications: synthetic rubber; synthetic fibers; paints; insecticides; fungicides; water treatment processes; petroleum products and processes; fertilizers, and compressed and liquefied gases.

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Methyl n-propyl ketone may be used as the sole dewaxing solvent for lubricating oils. It offers two main advantages over the commonly used methyl ethyl ketone-aromatic mixtures.

- Less Refrigeration Needed — Methyl n-propyl ketone allows a 10 to 15 degree saving in refrigeration since the dewaxing temperature is the same as the pour point of the finished lubricant.
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26 Portland Place, London W 1, about $4.90.

This book, written by names famous in British science, is an encyclopedia to the elements of science in petroleum. The contents are broken in six parts: exploration and production, manufacturing and refining of petroleum products, their properties and utilization, tests and their significance, and transportation and distribution.

This second edition, as the first edition, reviews the developments in the specialized field and brings the recent developments up to date. Refiners will be most interested in the third part of the book on manufacturing and refining petroleum products. This section is broken down into distribution, cracking, refining of petroleum products, manufacturing of asphaltic bitumen, and chemicals of petroleum.

Chemical Processes

Chemical Process Principles, Part I—Material and Energy Balances, Olaf A. Hougen, Kenneth M. Watson and Roland A. Ragatz, John Wiley & Sons Inc., New York 16, 504 pp., $8.50.

The second edition of this well-known volume covers certain industrially important principles of chemistry and physics. The book gives intensive quantitative training in the practical applications of the principles of physical chemistry in the solution of complicated industrial problems and in methods of predicting missing physicochemical data from generalized principles.

In addition, through recent developments in thermodynamics and kinetics, these principles have been intergrated into procedures for process design and analysis with the objective of arriving at optimum economic results from a minimum of pilot-plant or test data.

API Publishes New Manual On Plant Fire Prevention

American Petroleum Institute has published a new fire prevention manual for natural gasoline plants.

The manual, containing recommendations for fire prevention equipment and employe training programs in various kinds of natural gasoline and cycling plants, was prepared primarily for those type plants, but is reported to also have broad application in gas compression stations.

Written under the auspices of the Natural Gasoline committee of the Institute's Central Committee on Fire Protection and Accident Prevention, the manual may be obtained at the organization's New York headquarters, 50 West 50th Street. it is priced at 50 cents a copy.

Fundamentals of Catalysis

Catalysis, Vol. 2: Fundamental Principles, Part 2, edited by Paul H. Emmett, Reinhold Publishing Corporation, 430 Park Avenue, New York 22, 473 pp., $12.

This series of books provides research chemists with a well-integrated treatise on the physical chemistry of catalysis and catalytic processing. The first two volumes of the series cover the general approaches and tools to a basis knowledge of both homogeneous and heterogeneous catalysis.

Along with fundamental theory, considerable space is devoted to catalyst supporters, carriers and methods of preparation. Volume II concludes the discussion of fundamentals, and classifies catalysts according to the current ideas of solid state physics.

New Books . . .

Water Conditioning

Water Conditioning for Industry, by Sheppard T. Powell, McGraw-Hill Book Company Inc., 330 West 42nd Street, New York 36, 458 pp., $9.

This guide book points the way to improved water quality in a range of chapters covering water treatment from the simple removal of suspended solids to systems involving complex physicochemical principles. To accomplish this, the book begins with a review of fundamentals and goes on to describe in detail typical installations and operating methods needed to assure performance.

The book takes up additional matters related to water conditioning because of its effect on processing and on maintaining equipment. Such matters as cooling tower design and operation, corrosion, steam contamination, deaeration receive attention.

As a guide to taking necessary control measures, analytical processes for testing are included. Selected bibliography and footnotes supplement the manual.

New API Monograph Out

American Petroleum Institute's Committee on Fundamental Research on Occurrence and Recovery of Petroleum has published a monograph entitled, "Some Properties of Lighter Hydrocarbons, Hydrogen Sulfide and Carbon Dioxide. Written by B. H. Sage and W. N. Lacey, the book costs $10 a copy. API members, however, will receive a special price of $6.

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- **Industrial Solvents** by Ibert Mellan — Price $12.00
- **The Physical Chemistry of Lubricating Oils** by A. Bondi — Price $10.00
- **Elements of Fractional Distillation** by C. S. Robinson and E. R. Gilliland — Price $ 7.50
- **The Chemistry of the Non-Benzenoid Hydrocarbons** by Benjamin T. Brooks — Price $12.00
- **Methods of Analysis of Fuels and Oils** by O. H. Berdill — Price $17.00
- **Chemical Engineers' Handbook** by J. R. Campbell and W. Gibb — Price $ 4.00

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AROUND THE WORLD

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For more data on advertised products, use Readers' Service Cards, last page.

What Suppliers Are Doing . . .

Wentworth | Miller | Winemiller | Crowe | Egan | Finn | Everett | Juhan | Loper

Clarence S. Wentworth, formerly manager of **Worthington Corporation's** Detroit district office, has been appointed sales manager for the company's Central region.

L. M. Miller has been named eastern regional sales manager for the Chemical division of **Armour and Company**, with headquarters at North Bergen, N. J. Formerly manager of the division's Market Development department in Chicago, he succeeds the late Kenneth E. Johnson. E. L. Rhoads Jr., formerly an assistant manager in the company's derivatives department, replaces Miller as manager of market development.

William H. Winemiller, recently appointed assistant sales manager of the Refractories division of **Norton Company**, replaces Kenric H. Bird, retired. He will be responsible for refractories engineers, refractories sales engineering and the division's Worcester, Mass., sales office.

R. C. Crowe has been appointed to the sales staff of the **Wolverine Tube** division of Calumet & Hecla Inc. Associated with Wolverine for more than five years, he was divisional industrial and public relations supervisor. He will serve the company's sales territory in Southeastern Michigan.

K. F. Egan has been transferred by the Wolverine division to Rochester, N. Y., where he will serve the company's sales staff in upper New York State. Formerly he covered sales in Boston and environs.

E. J. Finn, formerly in Wolverine's Southeastern Michigan sales territory, has been transferred to Boston.

Charles T. Everett has been elected president and general manager of **Beaver Pipe Tools Inc.**, in Warren, Ohio. Formerly associated with Bingham-Herbrand Corporation, he joined the Beaver firm last year as executive vice president and general manager. He also will serve as a director.

Ben H. Juhan has been appointed manager of the Grating division of **Kerrigan Iron Works Inc.**, succeeding Art Drye. He was engaged previously in industrial management work with the Tennessee Aircraft Corporation.

Ben H. Loper, technical representative for the Refinery Chemicals department of **American Cyanamid Company**, has been transferred to Houston, where he will handle the firm's sales office there as well as its offices in Tulsa and Los Angeles. Formerly located with the department in New York, he also served the company in its offices at Stamford, Conn.; Fort Worth, Texas; and Michigan City, Ind.

Warne | Murray | Meier | Rearick | Evans | Edgecomb | Meiter | Hazel | Hopkins

Frederick P. Warne, formerly engaged in the practice of law in New York, has become general counsel of **Etayl Corporation**, succeeding **William R. Perdue**, who was recently elected vice president and treasurer.

Howard Murray, formerly in charge of the Houston office of **Philadelphia Gear Works** for four years, has been transferred to the main office at Philadelphia to assume duties as general manager of sales.

S. A. Meier, a sales engineer in the Los Angeles office of **American Blower Corporation**, has been appointed manager of a direct factory branch office recently opened by the firm at Phoenix, Ariz.

Glen H. Rearick, formerly in charge of the Alliance, Ohio, plant of the Tubular Products division of **Babcock & Wilcox Company**, has been placed in charge of the Milwaukee, Wis., plant included in the assets and business acquired by B&W from Globe Steel Tubes Company. The plant has become a part of B&W's Tubular Products division. W. C. Buchanan, formerly president of Globe, has consented to remain with B&W in an advisory capacity and has been elected a vice president-consultant.

Sidley O. Evans has been appointed to the newly created position of manager of tubing operations of B&W's Tubular Products division plant at Beaver Falls, Pa. He was formerly superintendent of the Extrusion department.

David A. Edgecomb has been named to succeed Evans as superintendent of the Extrusion department. He was formerly assistant superintendent of the department.

William A. Meiter, central sales manager of **Worthington Corporation**, has been promoted to general sales manager. He succeeds Thomas J. Kehane, who has been promoted to vice president in charge of sales. Meiter will make his headquarters at Worthington's executive offices at Harrison, N. J.

M. F. Hazel, director of engineering for the Oil Well Supply division of **United States Steel Corporation**, has been named vice president, sales. Alex Quayle, formerly chief engineer, will succeed Hazel in his old post. Other executive changes at "Oilwell": Lloyd E. Tracy, former vice president, sales, to vice president, merchandise; Dan H. Barr, general merchandise manager, to assistant to vice president, sales; Ralph W. Rager, former vice president, administrative, to vice president, manufacturing; and Gordon M. Amstutz, formerly general works manager, to assistant to the vice president, manufacturing.

Charles W. Hopkins, who has been with U. S. Steel 27 years, has been named to head the new sales office opened recently at Dallas, Texas, by U. S. Steel's United States Steel Supply division. A. R. Schmitt, a veteran of 39 years with U. S. Steel, will assist Hopkins as customer service representative.

Johns-Manville Expands Merchandising Organization

Arthur W. Knight was appointed Pacific Coast merchandise manager for **John-Manville Corporation's** Industrial Products division in a recent expansion of the company's merchandising organization in that area. He formerly held several sales positions with the firm.

Other promotions in the organization:

Nothing Succeeds like Success

. . . Buell 'SF' Electric Precipitators PROVE IT AGAIN!

Spectacular on-the-job performance started engineers talking . . . and it's been music to our ears ever since.

Our engineering friends have marvelled at low maintenance costs . . . at brand new efficiency records . . . at the wide range of different and complex dust recovery problems that are being solved by Buell's 'SF' Electric Precipitators.

We will be happy to demonstrate the finer points at any time. Such standard Buell features as continuous rapping . . . convenient remote control from a central switchboard . . . the proved efficiency of the exclusive Buell Spiralectrode, are all elements of simple overall design.

Dozens of Buell 'SF' Electric Precipitators are already operating or in the works. Get the complete facts now. Write for our informative Brochure "The Collection and Recovery of Industrial Dusts" which tells about *all three* Buell Systems of industrial dust recovery. Write today! Buell Engineering Company, Department 21-B, 70 Pine St., New York 5, N. Y.

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20 Years of Engineered Efficiency in
DUST RECOVERY SYSTEMS

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

Lawrence M. Osborn, former sales representative in the Bay area, moved up to Pacific Coast staff manager for all Johns-Manville products except transite pipe, and H. C. Bruner, former special representative for transite pipe in the Los Angeles district, now Pacific Coast staff engineer for the Industrial Products division.

Cambridge Names Distributor

R. D. Travers Company, of Hamilton, Ont., has started distributing Cambridge Wire Cloth Company products throughout the entire Provinces of Ontario and Quebec. Cambridge is located at Cambridge, Md.

National Cylinder Gas Announces Four Changes

L. O. Morris has been named as district manager for Tube Turns, a division of National Cylinder Gas Company in one of four changes in the company's Western division. Formerly sales representative in Denver, Morris will head company operations in its Mid-Continent division, with headquarters in Tulsa.

Other transfers in the organization: Daniel V. Pisano, former member of the sales staff in New York, appointed manager of the San Francisco district; Norton P. Bosemer, former manager at the Los Angeles office and plant, moved up to district manager in the Los Angeles area, and E. R. Muir, Jr., former sales representative at Seattle, named district manager for the Northwestern territory.

Boiler Manufacturer Sets Up New Department

Babcock & Wilcox Company's Boiler division has formed a new department which consolidates the contract and erection phases of its operations.

Heyward

Heading the new department, to be known as Contract and Erection, is Laurence W. Hayward, former assistant chief engineer of the division who has been named manager.

Divisional offices will be housed in a new building to be built near the company's largest manufacturing plant at Barberton, Ohio.

Associated with several leading engineering firms before he joined Babcock & Wilson in 1937, Hayward was appointed manager of the company's Service department in 1947 and assistant chief engineer of the Boiler division in 1953.

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Where, except at Robinson, can you obtain all these features in an orifice fitting for gas or liquid flow? Extreme accuracy of measurement is yours because the Robinson orifice is always centered with the piping and sealed against leakage. Orifice plates can be changed safely and quickly (3 to 5 minutes) with no interruption in flow, no hazards or gas loss. Various sizes and pressure ranges up to 3,600 PSI, flanged or welding neck.

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Same fine metering characteristics as the standard low pressure Type E shown above, but built for 6,000 PSI with positive pressure seal which becomes tighter as the pressure increases. Safety is assured because the fitting cannot be opened until the pressure is released. Available in flanged or welding neck. Compare Robinson point-by-point and you'll choose Robinson.

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ORIFICE PLATES AND HOLDERS standardize on Robinson orifice plates regardless of the make of fittings on your lines. Robinson plates conform rigidly to A.G.A. requirements. Our 30 year reputation for building accurate orifice plates is protection you can count upon.

Darling Valve Announces Changes in Sales Personnel

Changes in its sales organization have been announced by Darling Valve & Manufacturing Company.

B. E. Engstrom, Midwest sales manager for Darling's line of valves and hydrants, has been named to head a newly established sales office in Chicago.

Leon A. Hoffmeister, a sales engineer for Darling for more than 15 years, has been transferred to the New York offices, to be responsible for sales engineering on metal products, including valves and hydrants.

Frank C. Zeis, formerly of Missouri Construction & Machinery Company, has joined the company to handle sales of metal products.

Lewis M. Poag, recently in construction industry sales in the Cincinnati, Ohio, area, has been appointed to handle sales of metal products in that area.

B. F. Marcin, sales engineer, has been transferred from the New York area to Pittsburgh, where he will be responsible for sales of metal products.

Inco Appoints Engineer To Study Uses of Alloy

International Nickel Company has assigned Robert M. Wilson, Jr. as a development engineer in the power field for its development and research division.

The purpose of Wilson's assignment will be to assist other engineers in the division in the application of nickel alloys for use in power plants. Wilson has been a member of the division since 1946 when he joined as an engineer in its technical service section.

Stauffer Completes Plant

Stauffer Chemical Company has completed a new $800,000 plant for the manufacture of Crystex at Monongahela, Pa.

The new plant, designed and constructed by the company's engineering department, brings the number of Stauffer sulphur plants to eight. Other plants are located at Chauncey, N. Y.; Bayonne, N. Y.; Freeport, Texas; Harvey, La.; St. Louis, Mo.; Berkeley, Calif., and Richmond, Calif.

Crystex, a finely dispersed powered sul-

here's why FW modernization

can solve this problem at lowest overall cost

"BALANCED MODERNIZATION" by Foster Wheeler is more than just the addition of new process units in place of old ones. It includes maximum utilization of old but still serviceable equipment in the new plant. Old towers are adapted to new processes — old pumps, lines and tanks integrated into the new scheme. Scrapping of much costly equipment is avoided.

Over the past five years, Foster Wheeler has completely modernized a number of large refineries. This "know how" is at your service. *Foster Wheeler Corporation, 165 Broadway, New York 6, N. Y.*

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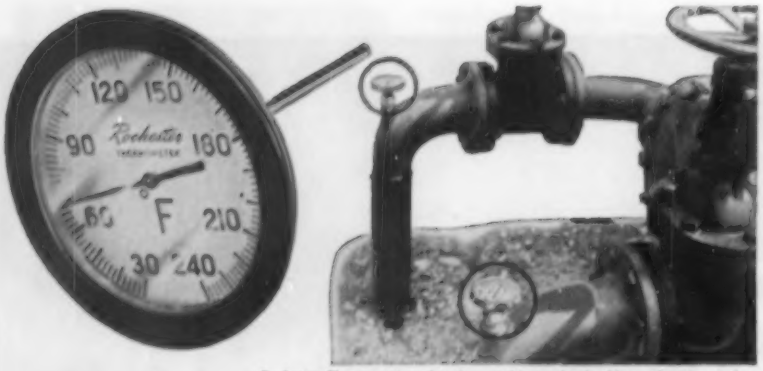

Rochester Thermometers give dependable service in this gas booster station.

Where are most of your thermometers?

Most refinery thermometers must be located outdoors, where they're subjected to weather, corrosive fumes, and salt air.

But these conditions are no longer problems with Rochester Thermometers. The all stainless steel welded case is practically immune to all these corrosive agents. Hermetically sealed, pressure-tight dial Rochester Thermometers will give you years of dependable service and *you* can recalibrate them from the outside.

For many installations, you'll be interested in the new Rochester Straight Form Thermometer. It has the same durability and dependability found in all Rochester Thermometers—PLUS a stem that can be mounted anywhere around the dial.

FOR FURTHER INFORMATION, call your Rochester representative, or write:

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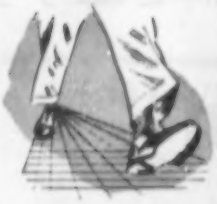
ROCHESTER GAUGES

DIAL THERMOMETERS GAUGES AMMETERS

WHERE SURE FOOTEDNESS COUNTS



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STEEL GRATING MAKES WALKS SAFER

Sturdy, one-piece construction with tops of all bars flush provides open steel flooring and stairs for safe, easier walking. Gary Grating is furnished in a wide variety of neat appearing designs and sizes—and is tailor-made to fit your needs. For complete description and installation pictures on Gary Welded Grating, Stair Treads and Gary-Irving Decking, ask for Catalog PR-25.

FREE SAMPLE
We'll send this handy paper weight if you request it on your company stationery.

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Suppliers . . .

phur, is prepared in company plants at Chaucey and Richmond.

Norris Sales Manager Named Vice President

Davidson

Miller

Hagaman

G. W. (Bill) Davidson, advanced to vice president in charge of sales, heads a list of three promotions in the sales staff of the W. C. Norris Company in Tulsa.

He is succeeded as sales manager by Art Miller, formerly his assistant. Paul Hagaman, who has been in charge of company sales in Tulsa, moves up to take Miller's place as assistant sales manager.

A veteran of 19 years with the Norris Company, Davidson moved to Tulsa as city salesman from the company's Wichita Falls, Texas territory in 1944. He was promoted to sales manager in 1946.

Miller handled Tulsa city sales prior to becoming assistant sales manager. Hagaman had served the company as a branch manager for 14 years before moving to Tulsa last year.

General Electric Engineer Takes Over Process Post

Robert G. Page has been appointed manufacturing engineering specialist for the distribution assemblies department of General Electric Company.

Page will handle new processes involving plant layout and methods of handling materials. He also will recommend sources for tools, dies and other facilities used in G. E.'s plants.

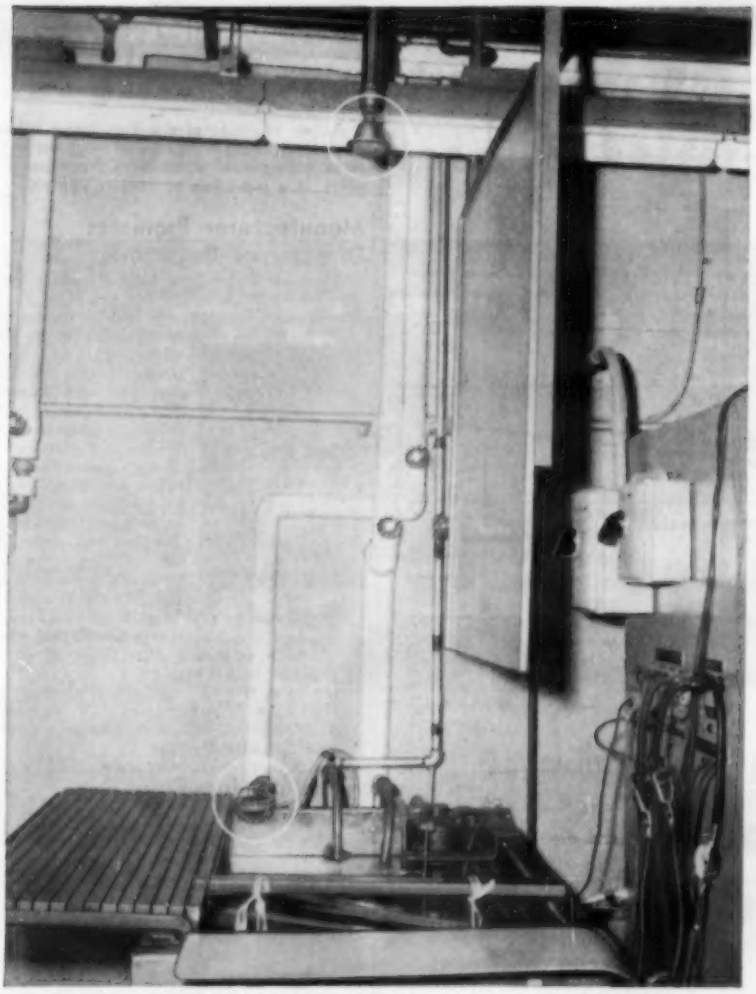
A graduate of Bowdoin College, Page received a company award in 1950 as a result of his efforts in developing a new type circuit breaker for the Navy.

Witco Buys Into Ultra

Witco Chemical Company has acquired a half interest in Ultra Chemical Works Inc., a Patterson, N. J. firm producing synthetic detergents, waxes and industrial chemicals. Officers and management of the Ultra company will continue as at present.

Rockwell Increases Research

Rockwell Manufacturing Company has announced a 50 percent expansion of its research and expansion program. According to C. A. Wiken, vice president of engineering and research, the company is



Everything looks quiet in this laboratory. But if flammable oil (below) should ignite, the FogFOAM head (above) would instantly release blanketing FogFOAM from the Rockwood SpotPROTECTION unit.

Hidden Danger Below- Spot Protection Above

Squelch a flammable liquid fire *before* it can do damage.

With Rockwood SpotPROTECTION you have such a fire hazard "covered" as the picture shows. The heat actuated device below would sense any rapid rise in temperature at once. Then, instantly, the FogFOAM head above would discharge a blanket of Rockwood FogFOAM and quench the blaze. This is Rockwood SpotPROTECTION — a worthwhile money-saving adjunct to your regular fire-fighting equipment.

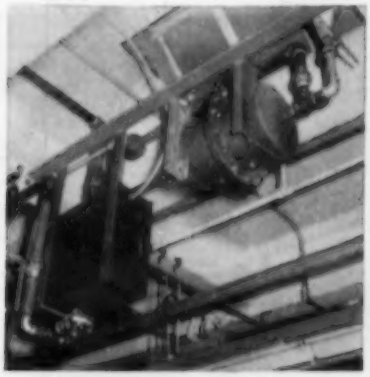
Where flammable liquid hazards exist, ordinary firefighting methods are often ineffective, and at times even dangerous. SpotPROTECTION snuffs out flaming vapors, *without agitating the surface of the liquid*, your best safety factor.

Put SpotPROTECTION to work for you. Send coupon for complete information.

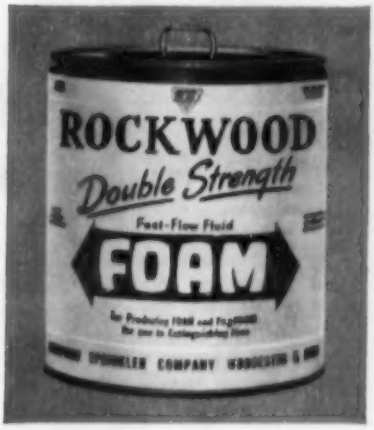
ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . to Cut Fire Losses

How Rockwood Engineers Water to Cut Fire Losses



The circular tank is both for storage and balanced pressure proportioning of Rockwood FOAM liquid into water at a predetermined percentage rate. Model "K" Deluge Valve automatically controls flow of FOAM solution to FogFOAM heads.



Rockwood Double Strength FOAM clings to surfaces...is an insulator — FOAM liquid flows freely at sub-zero temperatures. Excellent for extinguishing fires in gasoline, benzol and other highly volatile liquids as well as ordinary combustibles.

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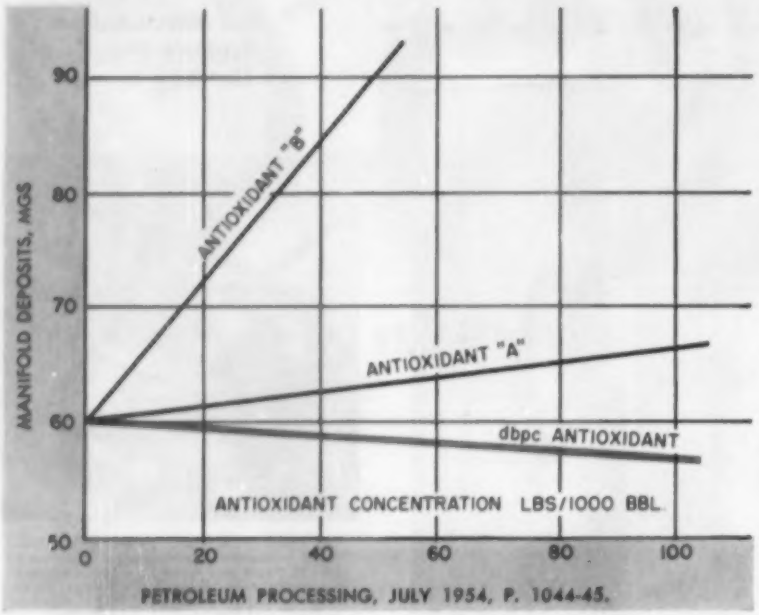
For more data on advertised products, use Readers' Service Cards, last page.

Engine Tests prove . . .



PETROLEUM PROCESSING, JULY 1954, P. 1044-45.

dbpc Antioxidant contributes NO manifold deposits

Three antioxidants were tested in a blend containing 60% catalytic cracked and 40% thermal cracked gasolines. The antioxidants tested were **dbpc**® inhibitor* and antioxidants "A" and "B" — other well-known commercial gasoline gum inhibitors.

The manifold test unit consisted of a specially-designed manifold attached to a single-cylinder, air-cooled engine, with provisions for control of fuel rate and temperature. The air-fuel mixture from the carburetor entered the manifold which was heated by two 500-watt, pancake electric heaters attached to the manifold exterior. Manifold temperature averaged 255° F.

dbpc (indicated in red) did not contribute to manifold deposits. Actually, it tended to *reduce* deposits. Antioxidants "A" and "B" however, *increased* manifold deposits.

dbpc is safe and easy to handle. It is economical, highly soluble in gasoline and is inert to extraction by caustic and water and the commonly used pipe corrosion inhibitor.

dbpc is also supplied in easy to handle liquid form as Impruvol 33® antioxidant.

For full information write:

*2, 6 di-tert-butyl-para-cresol

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Chemical Division, Dept. PR-25, Pittsburgh 19, Pennsylvania

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Suppliers . . .

concentrating on electrical research for the first time.

As an example of projects being taken up for research, Wiken cited work on telemetering systems which would operate all valve in a pipe line by remote control.

Manufacturer Promotes Director of Engineering

Thomas W. Johnson has been appointed director of engineering for the New York Air Brake Company. He will be in charge of engineering in the company's five divisions: Kinney Manufacturing and Aurora Pump companies and Dudco, Hydreco and Watertown divisions.

Johnson

An assistant to the firm's executive engineering consultant prior to his appointment, Johnson was active in shipbuilding, repair and maintenance for the Navy during World War II and was associated with the Bendix Aviation Corporation before he joined the brake firm.

He was senior research engineer in charge of a department of 130 engineers and technicians in the Bendix company's Eclipse Pioneer division.

Houston Alum Plant Goes Into Production

The first shipments of aluminum sulphate liquor went out this month from Consolidated Chemical's new alum plant in Houston.

As raw materials for the new production, sulphuric acid will come from the company's Houston plant and bauxite will be shipped from its mines in Arkansas.

Designed and engineered by the firm's engineering department and built by Brown & Root, the new plant increases Consolidated's alum plants to three. Other plants are in Springhill and Bastrop, La.

General American Promotes Cassard, Wetzel and Frisch

In changes announced by General American Transportation Corporation, George J. Cassard has been promoted to assistant general superintendent of the Terminal division. He had formerly been superintendent of the company's Goodhope, La., terminal. He will make his headquarters at General American's New Orleans office.

W. J. Wetzel has been promoted to assistant superintendent at Goodhope to superintendent.

Sol Frisch, who has been with General American ten years, has been promoted to district manager of the Plate and Welding division.

Conoflow Selects Two Firms As Southern Representatives

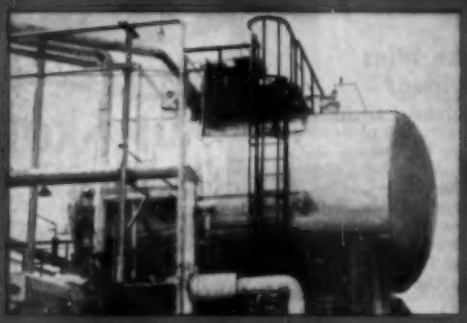
Conoflow Corporation has appointed two Southern firms as sales-engineering representatives for Cono controls. They are Williams Equipment Company, New Orleans, and Engineered Instrument Sales Company, Memphis, Tenn.

The New Orleans firm, headed by R. L. Williams, will service southeastern Lou-

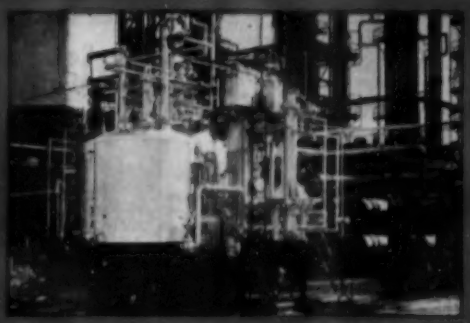
get higher profits, lower operating costs, reduced maintenance, better space use with

PETRECO®

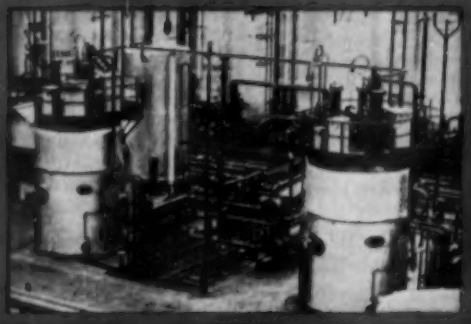
ELECTRIC PROCESSING



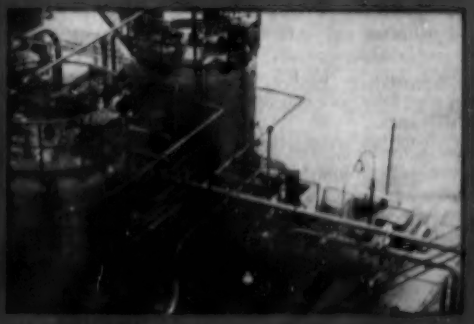
Petreco pioneered electric desalting and is the recognized leader in the field. Petreco offers a wide choice of desalting plant design, horizontal, vertical or spherical, all equally efficient.



Petreco distillate treating offers refiners an improved method for acid-contacting, caustic-scrubbing or doctor-treating. This new process is compact, continuous and automatic.



Petreco tube oil treating provides continuous, automatically-controlled acid treatment for lubricating oil and similar stocks. Operating in a closed system, it saves time, acid, space and guesswork.



Petreco desapontification removes ash-forming free caustic or sodium naphthenate soaps from heavy fuel stocks, enabling them to be marketed advantageously or used as a cracking charge.

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AR-2

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THERMOCOUPLE
HEAD

the head that's ahead in every way . . .

This new "Serv-Rite" thermocouple head is actually small enough to be held comfortably in the palm of your hand. But size is only one of the many features that make this thermocouple head really extraordinary. It is loaded with installation and service conveniences that any user of thermocouples will appreciate at once.

The body is of malleable iron, cadmium plated for durability. A new type friction lock assures easy removal or tightening of the cap — a quarter turn does it. An asbestos gasket makes the head dirt- and moisture-proof. With a choice of ½", ¾", or 1" IPS opening for the protecting tube, you can standardize on one style head.

The connector block is of a material especially selected to withstand, without damage, temperatures up to 900° F. in continuous service. Improvements over the conventional type of inserts greatly simplify the making of the lead wire connections. The complete thermocouple element, including connector block, can be easily withdrawn for inspection.

Install a "Serv-Rite" thermocouple head and see for yourself how much better it really is.

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isiana and southern Mississippi. The Memphis company, under James L. Shilane, will cover western Tennessee, northern Mississippi and eastern Arkansas.

B-I-F Names Works Manager

R. W. Pearce, manager of cholinizer sales for Builders Iron Foundry Industries Inc., has been promoted to works manager. He succeeds Earl H. Bradley, who was elected president of the organization last year.

Pearce

Pearce, who has served the company in various supervisory positions since he started to work in 1936, began as a machinist shortly after his graduation from Brown University.

Air Reduction Paper Wins Award in AIEE Division

Second prize in the Industrial Division, American Institute of Electrical Engineering, has been awarded to the paper entitled, "Atomic Film Cathode In Inert Gas Shielded Metal Arcs." The paper was coauthored by W. J. Greene, assistant director of metallurgical research, and Dr. A. Muller, director of metallurgical research, both at the Murray Hill, N. J., Research Laboratories of Air Reduction Company, Inc.

The paper details Air Reduction's development work in the field of emissive coated wires for the inert gas shielded metal arc welding process.

Du Pont Division Sets Up Technical Service Group

A new sales section and a new technical service group have been established by the Petroleum Chemicals division of the E. I. du Pont de Nemours & Company. The technical service group will prepare for new developments in the field of petroleum additives and improve world-wide customer service.

At the same time, new sales districts have been formed in the Middle Atlantic area with offices in Philadelphia, and in the Midwest, with offices in Detroit, to improve the domestic sales setup for tetraethyl lead and other additives.

Turbine Production Up

Increased production of mechanical drive turbines for industry and advances in the design of turbine-generator sets for the Navy during 1954 have been reported by Frederick S. Kohl, general manager of General Electric's Small Turbine and Supercharger department.

Kohl announced that approximately 400 mechanical drive turbines with a total horsepower rating of 155,000 were manufactured in 1954.

Ohio Registers Engineers

Two Cooper-Bessemer Corporation engineers have passed qualification examinations held last summer for registration in Ohio as professional engineers.

They are William Hartwick, a graduate of Michigan College of Mining and Tech-

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THREAD & GASKET ANTI-SEIZE COMPOUND

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Contains copper flake and metallic lead

Provides complete protection against wear and tear—seizure, galling, leakage and corrosion.

For high temperature refinery service—stills, super heaters, headers, hand-hole and manhole plates, cylinder heads, engines, heat exchangers, valves and pumps.

KOPR-KOTE will remain suspended and not deterioriate, dry out or harden, even when exposed to atmosphere. Impervious to air, water, steam, oils, ammonia and hydrocarbons when made up.

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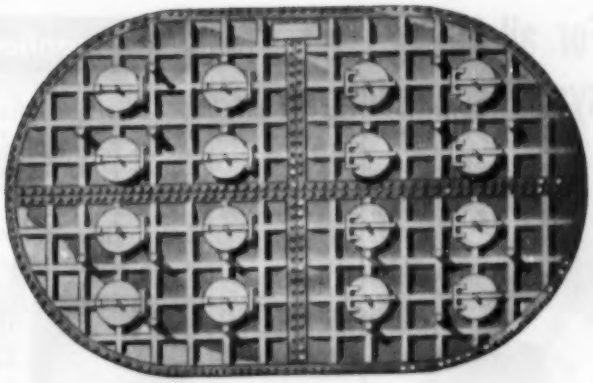

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Use Bridgeport Arsenical Admiralty

Admiralty, *plus arsenic*, in this Bridgeport Condenser Tube Alloy gives good corrosion resistance to most types of circulating waters—in seaboard power stations as well as inland installations.

Bridgeport Arsenical Admiralty is highly resistant to biofouling since it is unaffected by mild chlorination. The arsenic acts as an inhibitor to dezincification.

This alloy is only one of Bridgeport's many Condenser Tube Alloys made to A.S.T.M. Standards to meet various types of corrosion problems. Bridgeport's Technical Service and Corrosion Laboratories are available to help you select the alloy best suited to your operating conditions. Call your local Bridgeport Sales Office to use this service to your advantage.

Write for your copy of Bridgeport's Condenser and Heat Exchanger Handbook... 156 pages of valuable data on condenser tube alloys, applications and corrosion problems.

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nology who joined the Ohio firm in 1948, and Edgar Sampson, a Ohio State University graduate who was associated with Dayton Malleable Iron Company before he joined Cooper-Bessemer last year.

Long-Time Hoffman Man To Assist Worthington Head

Bowdoin

George E. Bowdoin, former president of U. S. Hoffman Machinery Corporation, has joined Worthington Corporation as assistant to the president. Bowdoin, associated with the Hoffman organization for 24 years, was named as its executive president in 1947 and served as president from 1952 until he resigned in 1954.

Honeywell Appoints 42 to Field Sales Organization

Forty-two sales engineers were recently added to the field sales force of Minneapolis-Honeywell Regulator Company's Industrial division in 25 branch offices located in 23 U. S. cities and 2 Canadian cities.

At the same time, 18 service engineers were also added to the firm's field sales force, taking positions in 12 U. S. cities and 1 Canadian.

The new appointees include: William N. Wallace, Stig G. Gavelin and Richard P. Ash, San Francisco; Jack Phillips and John M. Robinson, Los Angeles; Joseph H. Mitchell, John M. Kennedy and Ronald L. Anderson, Houston; Henry R. Rivitz, William E. Ware and Henry T. Vaders, Philadelphia; Walter W. Johnson, Columbus; Frank A. Patterson, James R. Alexander, Owen N. Smith and Kingsley G. Drake, Montreal; Reuben E. Hopkins, Peoria; William D. Robertson, Louis H. Johnson and Joseph T. England, Union; Raymond S. Johnston, Dayton; John P. McSweeney, Cleveland, and Herbert D. Couture, Charlotte.

Also, Robert L. Muha and Tom J. Chakos, Chicago; Francis J. Deinzer, Buffalo; Bruce M. Harman, Baltimore; Robert H. Schaffer, Detroit; Clarence L. Ledin, Boston; James B. Harper, Clifford R. Hawker, Ralph Parker and Walter Harasym, Toronto; Delos P. Young, Portland, Ore.; Eldred E. Jones, Wichita; Gordon D. Fourman, Knoxville; Richard T. Flanagan and Edward J. Herold, New York; James W. Lovill, Cincinnati; Earl J. Finear, Dallas; Raymond J. Miotke, Milwaukee, and Alvin E. Smith, Seattle.

Wolverine Stages Seminar

Leading engineers from the petroleum, petro-chemical and refining industries in the Southwest met in Houston recently for a two-day seminar entitled "Opportunity." Sponsored by Wolverine Tube Division of Calumet & Hecla Inc., the seminar was conducted by Dr. Donald A. Katz, professor of chemical engineering at the University of Michigan.

Paul-Condit Has Changes

Paul-Condit Company has opened new offices and warehousing facilities at 1025 Lehall, Houston. John Kensel, formerly of-

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QUICKLY—PERMANENTLY

SKINNER-SEAL PIPE JOINT CLAMPS stop leaks at joints. Put on under pressure—without interruption of service. Quick, simple, lasting repair. Sizes 1/2" to 24" incl. in stock.

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customer reduces estimate of job cost $24,000 by switch to WELDOLETS

An oil piping contract recently was reduced by $24,000 by changing specifications to WELDOLET welding fittings.

Comparable savings are possible on almost every piping contract. It will pay you to examine this positive means of reducing your piping costs. Write us for details.

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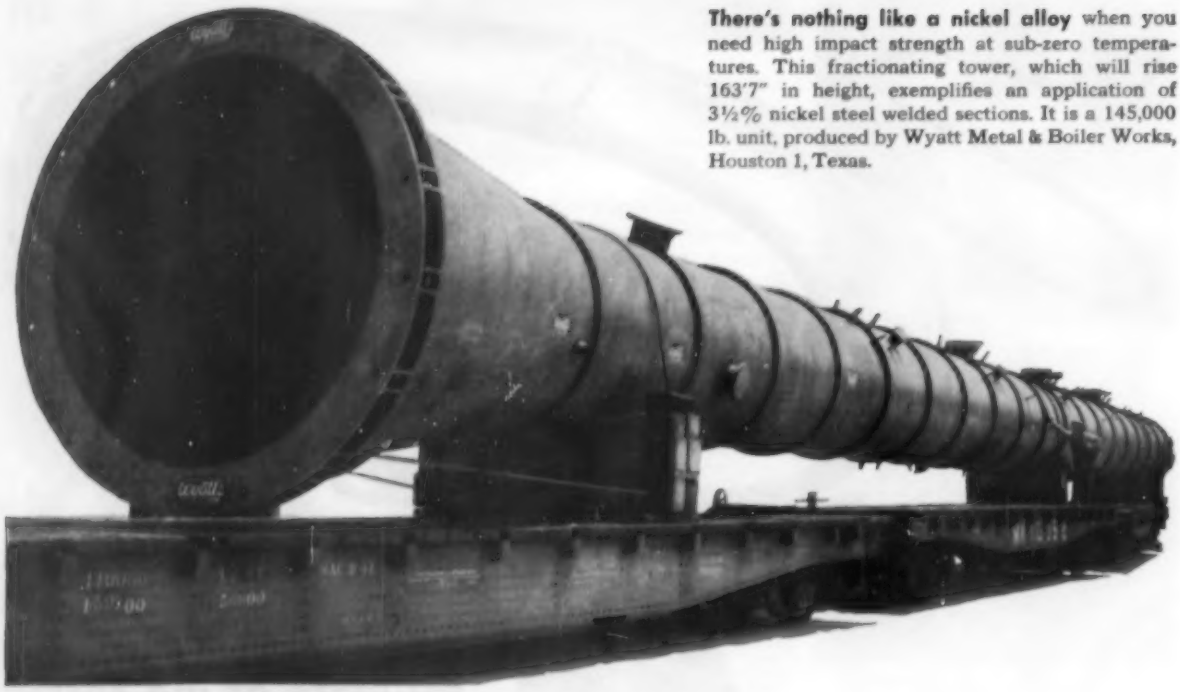

There's nothing like a nickel alloy when you need high impact strength at sub-zero temperatures. This fractionating tower, which will rise 163'7" in height, exemplifies an application of 3½% nickel steel welded sections. It is a 145,000 lb. unit, produced by Wyatt Metal & Boiler Works, Houston 1, Texas.

A Tower of Strength at -160° F.

YOU KNOW how low-temperature embrittlement affects equipment, particularly that built for controlling reactions, liquefaction and fractionation of gases . . .

And you know how carbon steels and many alloy steels quickly lose impact strength when temperatures fall below −50° F.

A solution to the problem, however, requires no hand-tailored steel. In fact, when your equipment needs toughness in addition to good strength properties at sub-zero temperatures, you can safely give the job to an appropriate *standard grade of nickel alloy steel.*

For an example, look at the fractionating tower, above. The builder, Wyatt Metal & Boiler Works of Houston, Texas, produced it from a standard grade of low carbon nickel alloy steel. This grade, containing 3½ percent nickel, was selected for ready response to fabricating operations and welding, as well as for ability to resist shock at temperatures down to −160° F.

Several other standard grades of low carbon nickel alloy steels, likewise, offer impact strength at levels that qualify them for low-temperature use. In addition, all these grades provide properties to meet a variety of fabricating and service demands.

No matter what your metal problem, you can usually solve it by using the correct nickel alloy. Send details of *your* difficulty, for our suggestions. As the first step toward getting rid of such trouble . . . write us now.

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REVOLUTIONARY CONSTRUCTION

Smooth, efficient contours . . . no weld "blob" around edge of ring. The flange is precision rabbeted into the ring joint gasket making deformation at that point impossible.

MAC-IRON offers a complete listing of line and temporary strainers. The latter of woven wire, perforated basket and conical . . . all for use with raised face, and ring joint flanges.

A large stock on hand is maintained; special strainers made to specification. Write direct for a catalog and complete information.

The Mack Iron Works Company
Warren and Water Sts. Sandusky, O.

Suppliers . . .

fice engineer in the Houston office, has been transferred to a newly established Baton Rouge, La., office. Kensel is succeeded in Houston by F. L. Magel.

New Division Created

Manning, Maxwell & Moore Inc. has formed a new Industrial Controls division at its plant in Stratford, Conn. Eugene M. Moore, who has held a variety of managerial positions since he joined the company in 1937, was named to head the new division. Karl W. Peterson will be sales manager, and C. Garland Roper, chief engineer.

Moore

Firm Opens Houston Office

Clarence M. Holden, former president of General Industrial Supply Corporation in Fort Worth and until recently contract administrator for Rohr Aircraft Corporation in California, has been named representative for Born Engineering Company in the Texas Gulf Coast area.

Holden will manage an office to be opened in Houston and direct sales operations for the company's Upflo heaters in that area. The firm headquarters in Tulsa.

Relocates in New Jersey

Vanton Pump & Equipment Corporation has moved its executive and sales offices to the company's plant location at Hillside, N. J. Offices formerly were in the Empire State Building.

Management, sales and engineering activities were consolidated as a result of expanded facilities at Hillside and a stepped-up program which has demanded closer liaison and communications.

Steel Company Bought

South Chester Tube Company, a Chester, Pa. firm, has purchased Dodge Steel Company, a Philadelphia manufacturer of electric steel castings.

The newly-acquired firm will be operated as a wholly owned subsidiary of the Chester company, retaining its name and separate identity. Its products range from machinery and equipment parts to specially-designed pressure units for valves, pumps and turbines.

To Represent Childers

Power Plant Efficiency Company, Indianapolis, Ind., has been appointed sales and engineering representatives of Childers Manufacturing Company aluminum weather-proof jacketing. Power Plant Efficeney's territory will consist of central Indiana, including Fort Wayne and Evansville.

Appointed President's Aid

David K. Tomer has been appointed administrative assistant to W. Cordes Snyder, Jr., president of Blaw-Knox Company.

Tomer, an alumnus of Carnegie Institute of Technology and a registered professional engineer in Pennsylvania, joined the Pittsburgh firm in 1953.

Before joining Blaw-Knox, he was em-

the Means Modern of

ECONOMICAL PROTECTION From
CORROSION DAMPNESS
HEAT COLD
and Many Chemical Fumes

—SABCO—
ALUMINUM PAINT
THE WONDER COAT
NEEDS NO UNDERCOAT

2 Protective Coatings
In 1 Application

CONTROLS CORROSION

INSULATES Against Heat, Cold, Moisture. Ideal for tanks, lines, structures

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AMERICAN SAND BANUM CO.
Established 1926
9 Rockefeller Plaza
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FOR REPLACEMENTS ORDER HIGH PRESSURE

GAGE GLASSES

MAGNIFYING RED LINE

MASTER STANDARD RED LINE & CLEAR
Up to 500 lbs.

MASTER CLEAR & RED LINE EXTRA STRONG
Up to 600 lbs.

Made in Lengths up to 144" Long
And Outside Diameters ⅝", ½", ⅝", ¾", ⅞", 1", 1¼", 1½".

High Pressure Composition
ERNST RUBBER GASKETS
All sizes to fit your gages and valves

FIG. 21—Lip Mold

FIG. 22—Standard

ERNST WATER COLUMN & GAGE CO.
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"International" TOP ENTERING MIXERS

NEW TYPE MIXER 1 TO 50 H.P.

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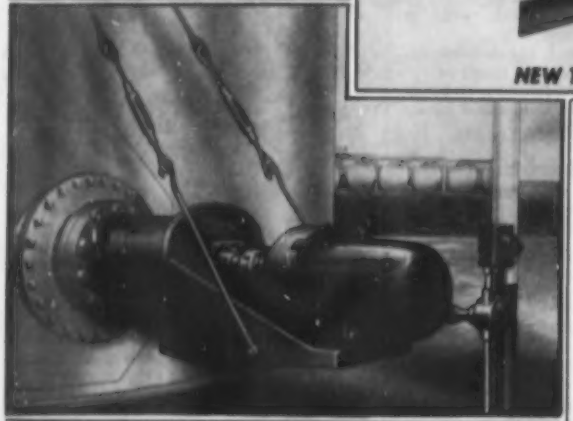

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Suppliers . . .

ployed with Atlantic Refining Company at Philadelphia. For 16 years he was with Koppers Company serving in a variety of engineering and management positions.

Builder Hires Former Coach

Buddy Brothers, former head football coach at the University of Tulsa, has been appointed assistant to Clyde W. Wyant, president of Tuloma Builders Inc., a Tulsa engineering and construction firm.

Brothers, who twice named "Coach of the Year" in the Missouri Valley conference, will handle the company's public relations, safety program and employes' trust fund.

Transfers to West Coast

Alden H. Webber, field sales engineer for Bristlo Company, has been transferred from New York to take over the company's Seattle territory.

Webber, who holds several patents in instrument design and parts has been with the firm since 1943.

Haering Names Field Engineer

Dan A. Doolittle has been named field engineering for D. W. Haering & Company's Southern California territory, succeeding Paul A. Dobson, who is retiring after 15 years with the company. Doolittle formerly was an engineer in the firm's laboratories.

Starts New Sales Activity

A new field engineering activity designed to assist the process industries in the problem of applying analytical instrumentation has been announced by Beckman Instruments, Inc.

Cochrane Appoints Turbine

Turbine Equipment Company has been appointed representative for Cochrane Corporation for the Upper Eastern New York State area. Turbine Equipment will handle water conditioning equipment, steam specialties and condensate booster and return systems manufactured by Cochrane.

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CHEMICAL ENGINEERS

Graduate Chemical Engineers with minimum 3 years' process design experience in oil refinery or surface oil producing facilities.

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Towers & Columns

8′ x 28′	2—7′ x 57′ (400#)	2′ x 75′
7′-6″ x 56′	6′ x 63′	4′ x 47′ (250#)
7′-4″ x 70′	6′ x 58′ Chr. clad	2′ x 60′ (560#)
2′ x 45′ (250#)		

Heat Exchangers

2—1125 sq. ft. (850#)	5—360 sq. ft.
1—1800 sq. ft., Adm.	1—302 sq. ft., Cu-Ni, unused
1—1000 sq. ft.	4—260 sq. ft.
1—600 sq. ft., Adm.	1—245 sq. ft., Adm. (unused)
5—424 sq. ft., Adm.	5—Karbate 188,177 sq. ft., unused

Liquidation 7000 Barrel Refinery

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Consisting of Towers, Heat Exchangers, Tanks, Vessels, Pumps, Compressors, Ethyl Lead Plant, Complete Truck Loading Rack with Pumps, Meters, etc. Ask for Bulletin #1254.

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CAIRO UNIVERSITY, FACULTY OF ENGINEERING, announces a vacancy in the post of Professor of Petroleum Refinery Engineering. Requirements are Ph.D., experience, and contributions to literature. Candidate must have at least 5 years' experience as Assistant Professor. Applications will be considered from candidates not fulfilling this condition if they have had some experience in university teaching, provided all other conditions are satisfied. Salary 900 - 1,500 Egyptian pounds (one pound equals $2.87), plus additional allowances, bonuses and travel allowance. Minimum contract two years, renewable to five. Lectures given in English. Application in full detail should be sent to Dean, Faculty of Engineering, Giza, Cairo, Egypt, to arrive before March 1, 1955.

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Equipment Engineer

Petroleum and Chemical Industries

To a responsible engineer interested in performing analyses of equipment selection and application problems . . . in solving complex problems in dynamic vibration and corrosion in petroleum and chemical service . . . and in the development of special equipment . . . we offer a permanent position on our senior staff.

To qualify, applicants should have advanced technical knowledge in design and development of centrifugal and reciprocating machines and packed units used in the oil and chemical fields and in power plant auxiliaries. An engineering degree and a minimum of five years' experience on mechanical equipment is essential.

If you feel that this position could absorb your interests and utilize your capabilities to their fullest extent, please write us complete details, in confidence, including your salary requirements.

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CHIEF CHEMIST

Independent refinery requires graduate chemist or chemical engineer, reporting directly to Plant Manager, to supervise testing and analytical laboratory. Must have minimum of four years refinery laboratory experience. Duties will include product blending and quality control.

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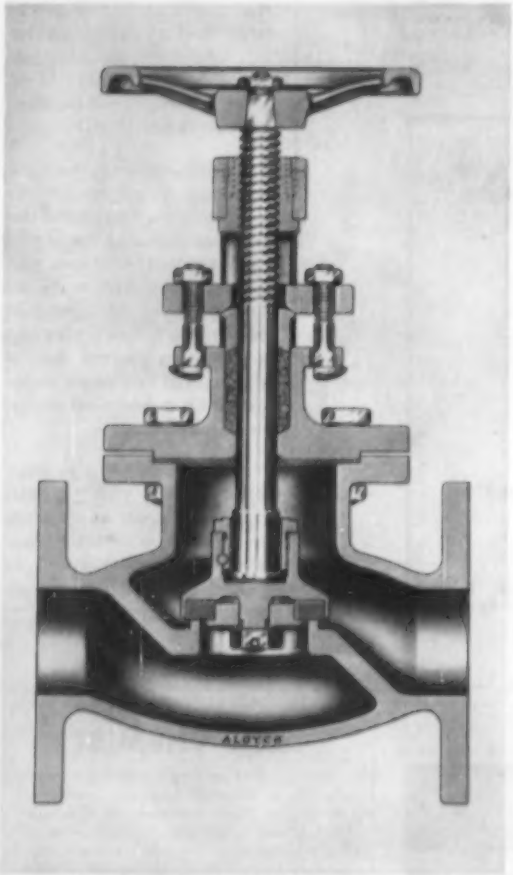
Aloyco valves with renewable Teflon discs out-last metal-to-metal seated valves



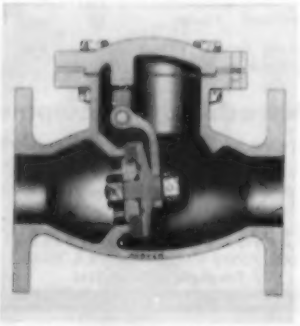
In handling volatile or elusive fluids, the slightest corrosion of a metal valve seating surface or packing gland is bound to cause leakage.

With Teflon discs, however, this leakage is prevented because of Teflon's ability – even when adjoining metal is slightly corroded – to form a gas-tight seal under compression. Add to this the fact that Teflon discs and seats are renewable when worn and you can see why we're using them in so many Aloyco valves.

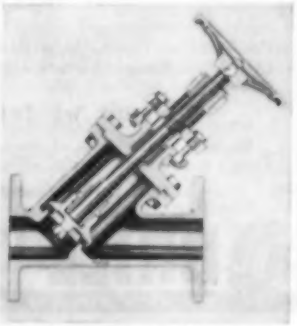
Teflon, the new DuPont plastic, has outstanding resistance to virtually all corrosive chemicals up to 550° F. It's used as bonnet gasket, packing and seating material in many Aloyco valves specially designed and constructed to take advantage of its remarkable properties.

You can specify Teflon in plain or jacketed, screwed end or flanged Globe, Y, Angle, Swing Check, Needle, Plug Gate or Sampling valves in a variety of alloys and sizes. Send coupon for details.

ALOYCO GLOBE VALVE features special holder for renewable Teflon disc to prevent force-out even under heavy overloads.



ALOYCO SWING CHECK VALVE offers greater seat tightness for tighter closing and longer life with renewable Teflon disc.



ALOYCO Y VALVE is easier to maintain and repair, thanks to Teflon disc. Also readies this valve for vacuum service. 3.4

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Linden, New Jersey

Gentlemen:

I am interested in Aloyco jacketed valves. Please send me a free copy of your Bulletin No. 6.

Name_____

Firm_____

Address_____

City_____ Zone____ State_____

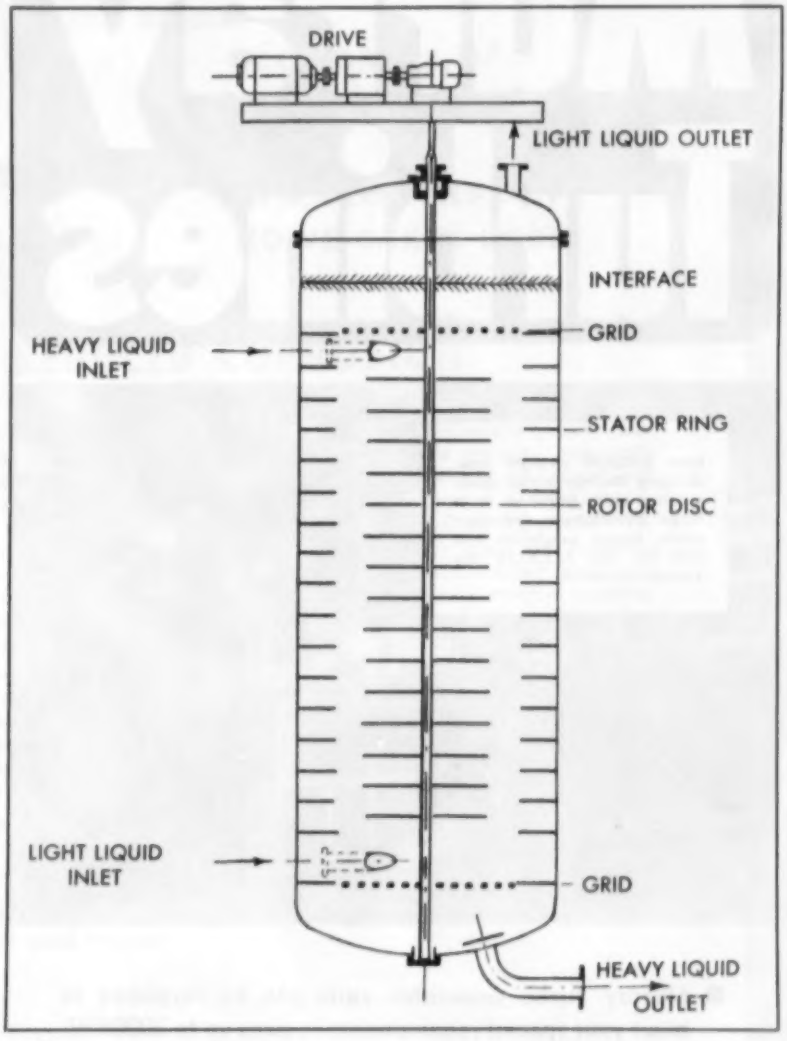
Longer Lasting
ALOYCO
VALVES
1ST IN CORROSIVE SERVICE

For more data on advertised products, use Readers' Service Cards, last page.

What's New In Equipment . . .

Inexpensive to build, more economical to operate, this new development offers a much needed solution to problems of . . . .

Liquid-Liquid Extraction



Shell Development Company has just announced for licensing a new extraction apparatus, designed to be more efficient than any conventional equipment in current use, with wide applications in the refining and petrochemical industries.

Called the Rotating Disc Contactor, this equipment is designed to be both inexpensive to build and more economical to operate than extraction tools such as packed towers, mixer-settler systems, and towers with contact trays.

One important initial application is in extraction of lubricating oil fractions. Other uses, both proven and potential, include: caustic treatment of light distillates, extraction of aromatics, deasphalting, separation of chemical and pharmaceutical liquid organics, treatment of plant effluents, and as a staged chemical reactor. There are now six of these units in commercial operation throughout the world.

The Rotating Disc Contactor is a vertical cylindrical tower. Within the tower, a vertical Rotor shaft bearing a series of flat, smooth discs whose diameters are about half the width of the tower, rotates to provide gentle but effective agitation of liquids passing through the unit. Stator rings are fixed to the inside wall of the tower between the discs. The ID of the rings are greater than the OD of the discs, allowing easy removal of the shaft.

In continuous operation, the heavy liquid is piped into the upper part of the tower, and the lighter liquid is pumped into the lower section. Gravity, in combination with the adjusted rotation of the discs on the shaft (Rotor speed is variable and may go up to several hundred rpm.), causes contact and controlled dispersion. The light phase is then taken from the top of the unit and the heavy phase from the bottom.

Shell Development has further announced that The Lummus Company and the Turbo-Mixer division of General American Transportation Corporation have been licensed to engineer and build this equipment.

For complete engineering details, simply . . .

Circle E1 on Postcard

Recorder-Controller

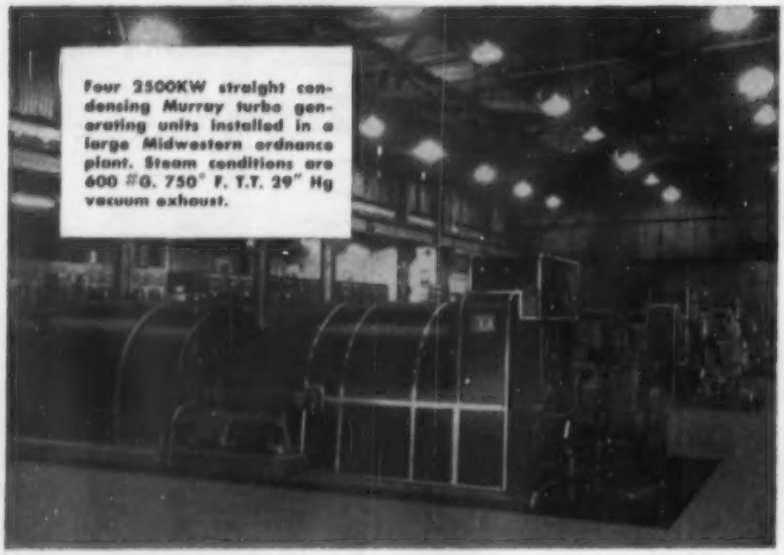
A sensitive and accurate self balance recorder-controller has been developed for application in a wide range of industrial process operations by Robertshaw-Fulton Controls Company.

The new instrument, called the Series 42 Radio Frequency Capacitance Bridge, was designed primarily for the measurement and control of levels of liquids, granular solids, interface and other conducting or non-conducting substances. Because it is of the capacitance type, the new instrument may be used for other variables, such as moisture content or composition, which cause a direct change in dielectric constant.

Electrical and pneumatic control forms can be incorporated within the single housing of the Series 42. Instruments are also available in explosion-proof housings suitable for Class 1, C and D hazardous applications.

A product of the company's Fielden Instrument division, the new device provides the refining, natural gasoline, and petrochemical industries with a recording,

Murray Turbines



Four 2500KW straight condensing Murray turbo generating units installed in a large Midwestern ordnance plant. Steam conditions are 600 #G. 750° F. T.T. 29" Hg vacuum exhaust.

● Murray Turbo Generator units can be furnished to meet your special requirements in sizes up to 3000KW. Condensing and non-condensing types with or without extraction and/or mixed pressure features can be furnished. Whether you require a small inexpensive standby unit or a highly efficient, and reliable source of power, Murray has a design to fit your needs. Consult your local Murray representative who will gladly help you select the unit most economically suited to your conditions.

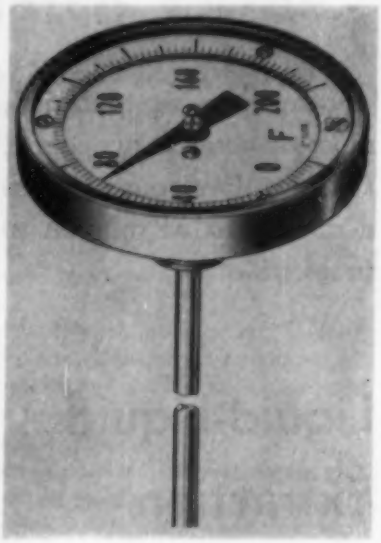
MURRAY IRON WORKS COMPANY
BURLINGTON, IOWA

Builders of Steam Power Equipment for Three Quarters of a Century

New Equipment . . .

indicating and controlling instrument accurate to within ¼ of 1 percent.

Circle E2 on Postcard



Anti-Parallax Thermometer

A new stainless steel Bi-Metal Dial Thermometer developed by Manning Maxwell & Moore now makes possible accurate reading of process temperature changes with the same ease and economy as pressure readings.

To assure high accuracy in reading, these thermometers are constructed with a new, anti-parallax "Maxivision" dial. Graduations are carried on a raised ring, set close to the cover glass, with the index-type hand at the same level. This design overcomes perspective effect of pointer above dial and practically eliminates any chance of error due to parallax.

Only 3-inch in diameter, the new thermometer has bi-metal coils welded to the stem plug and is accurately centered in the stem to eliminate the possibility of retard effect or inaccuracy caused by the coil rubbing on the side wall. The combination of the stainless steel case with a threaded stainless steel bezel and gasketed heavy glass front assure satisfactory operation under all conditions, and removes working parts from any danger due to corrosion.

Ranges are available from minus 80 F. to plus 1000 F, with dials graduated in either Fahrenheit or Centigrade.

Complete details are available on this new development in thermometers now. Just . . .

Circle E3 on Postcard

High Temperature Insulations

Fiberglas and Kaylo industrial heat insulations have been developed to meet the problems resulting from the increase of average temperatures of industrial processes. This increase in the past seven years has been from 350-500 to 500-700 degrees, and

This is the fourth in a series of brief summaries of the economics of electrical desalting. Earlier reports detailed the credits from increased crude capacity (averaging 4.6¢/bbl.), reduced exchanger, furnace, and tower maintenance (1.1¢/bbl.), and improving thermal and catalytic cracking yields (1.6¢/bbl.). The total of the five major credits for electrical desalting assure a payout of better than 100%. A complete report detailing credits of electrical desalting available upon request.

TECHNICAL REPORT

SUBJECT:

ECONOMICS OF ELECTRICAL DESALTING

FROM:

RESEARCH FILES OF HOWE-BAKER CORP.

FOURTH IN A SERIES

4. CREDITS FROM REDUCED CORROSION

Credits from Reduced Corrosion. Earlier reports in this series discussed the considerable credits accruing as the result of electrical desalting, including the following: (1) increased crude capacity: essentially complete removal of entrained water permits replacement in a 10:1 ratio with crude, with no additional heat duty. This, coupled with the reduction in the number of downtimes required for equipment cleaning, nets a capacity increase of the magnitude of 4.6c/bbl. of crude. (2) Maintenance costs will be substantially reduced by the elimination of frequent exchanger cleanings, reduced fouling in tower trays and furnaces. Before-and-after records indicate a minimum credit of 1.1c/bbl. (3) Improved catalytic cracking yields are assured since catalyst poisoning from metallic oxides is substantially reduced. Similarly, thermal cracking yields of gasoline are aided by the elimination of salt which catalyzes the formation of coke and tar. The total credit for the average refiner will amount to at least 1.6c/bbl.

Electrical desalting received its initial impetus many years ago as a means of reducing the serious damages from corrosion. The salt in crude oil readily hydrolyzes to HCl and the attendant damage to vessels, trays, tower linings and overhead equipment is considerable, even when the best possible control measures of ammonia injection, etc. are used. The refiner wages a never-ending war on corrosion — and electrical desalting is one of his best tools.

All engineers have an inclination to discount those credits not readily subject to quantitative evaluation. In this case of evaluating corrosion losses, the temptation was resisted and careful records were maintained and studied over a period of years to ascribe a quantitative evaluation of the magnitude of the losses involved. Equipment studied included tower trays, lining, and other internals, exchanger tubes and baffles, overhead equipment including vapor lines and condensing equipment, furnace tubes, and headers. These studies established that removal of salt through electrical desalting reduces corrosion damage to equipment by a minimum of 0.6c/bbl. of crude charged.

SUMMARY OF CREDITS

	c/Bbl
1. Increase Crude Capacity	4.6
2. Reduce Maintenance . . .	1.1
3. Improve Cracking Yields	1.6
✓ 4. Reduce Corrosion	0.6
5. Increase Tank Capacity .	0.2
Total Credits	8.1

Write today for your copy of the complete report to:

HOWE-BAKER CORPORATION
ESPERSON BUILDING HOUSTON, TEXAS

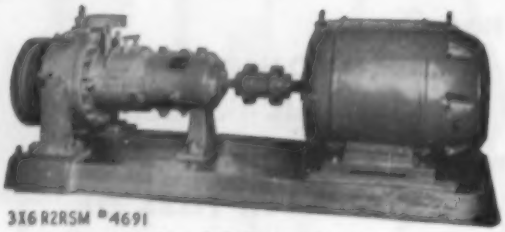
SPECIALISTS IN PETROLEUM EMULSIONS

Esso · ATLANTIC · SINCLAIR OILS · PETROLEUM MEMBER · PURE · HUMBLE · SUNOCO

OVER 1,000,000 BARRELS OF CRUDE PROCESSED DAILY BY THESE HOWE-BAKER CUSTOMERS

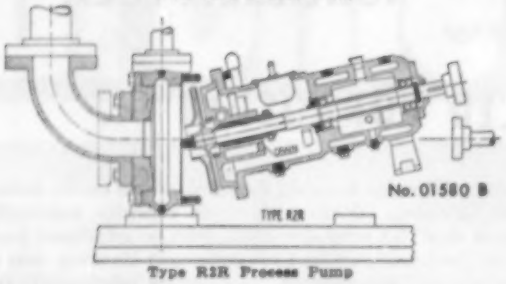
DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



3X6 R2RSM 4691

Type R2R Process Pump



Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R. Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute.
Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

BUILDERS OF OUTSTANDING PUMPS SINCE 1869

CENTRIFUGAL and RECIPROCATING PUMPS

4046N
Close Coupled Centrifugal Pump

4043 AA
Pedestal Mounted Centrifugal Pump

4728
Double Pedestal Bearing Centrifugal Pump

3510
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids

3833
Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump

3556
Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.

INDIANAPOLIS IND.

323 W TENTH ST.

Branch Offices: NEW YORK, N. Y., HOUSTON, TEXAS

Representatives in Principal Cities

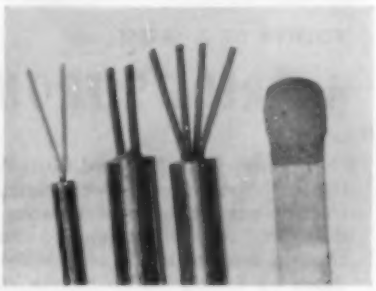
New Equipment . . .

industrial trends indicate that temperatures will go even higher in the future. The insulations provide improved process control, fuel conservation, and protection of operating personnel from high temperatures. Fiberglas insulations are effective to 900 degrees in Kaylo to 1200 degrees.

Complete technical details on these modern high temperature insulations are available now.

This item supplements the Owens-Corning Fiberglas Corporation data on pages 701-720 of The Refinery Catalog, 22nd Edition.

Circle E4 on Postcard



Pressure Thermocouple

Thermo Electric Company is introducing its new "Ceramo" thermocouple and thermocouple extension wires. These magnesium-oxide insulated, metallic clad wires are extremely small in diameter, very rugged, and readily formed. They are made in a variety of thermocouple materials, and in several gages and outside diameters. Different types of seamless metal tubing coverings are available. The thermocouple wires are made in lengths up to 30 feet and the extension wires in varying lengths up to 2000 feet, depending upon the type of metal tubing and outside diameter.

Extensions and thermocouples made of "Ceramo" wires can be formed easily to any configuration without short-circuiting. In fact, they can be bent on a radius as small as their diameter. The thermocouples will withstand pressures up to 40,000 psi.

"Ceramo" thermocouple wires are made in Iron-Constantan, Chromel-Alumel, Copper-Constantan, Chromel-Constantan, and Platinum-Rhodium Platinum. The wires are sheathed with seamless tubing of stainless steel (types 304, 310, and 347), Inconel, aluminum, or copper. The thermocouples are available in diameters of 1/16 inch, ⅛ inch and ¼ inch, respectively. For complete information on this new product, simply . . .

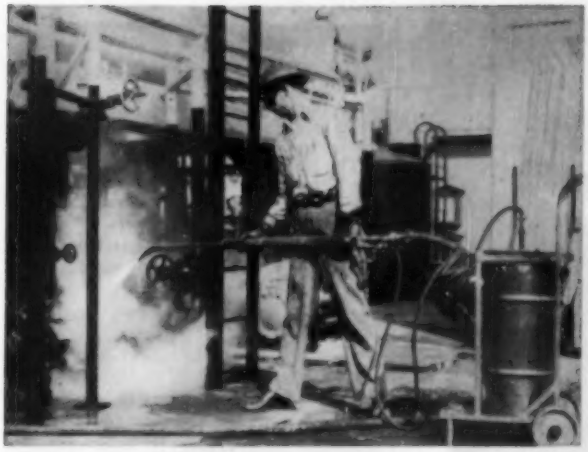
Circle E5 on Postcard

Bleeder Valve

A new stainless steel GRALOC vent-drain-bleeder valve has been designed for 20,000 psi safe working pressure or temperatures up to 1200 F.

A pressure-aided seat makes it leakproof for oil, water, gas or steam service. It is fabricated from a combination of types 410 and 416 stainless steel, making it suitable for essentially any fluid or atmosphere and providing a maximum resistance to galling.

Manufactured in ½-inch and ¾-inch sizes, these new valves may be used for vents and drains at the high and low points



Maintenance Cleaning Cut from Days to Hours at Western Refinery

Refinery finds Oakite Detergent applied with Oakite Steam Gun makes short work of cleaning prior to repainting.

THE cleaning problem this California refinery had was simple enough. It was one of removing all dirt, grease and muck from tanks, pumps and similar equipment. But actually doing the job was not so simple. It meant tedious scraping, wirebrushing, wiping by a sizable crew. It involved struggling with hard-to-get-at surfaces. Did the Oakite Man have a better answer?

He did—as a result of his wide refinery cleaning experience. For this particular case, he suggested the Oakite 384 Steam Gun. He helped Maintenance get started that morning. By afternoon, the plant superintendent stated, "One man did about two weeks' work today".

Proving that—
in industrial cleaning it always pays to consult Oakite.

YOUR OAKITE TECHNICAL SERVICE REPRESENTATIVE.—His experience is yours to draw on. He knows "cleaning engineering" and the conditions under which refinery cleaning can be best performed. His responsibility only *begins* when you order materials. He keeps in touch with you. He sees to it that the job is done right the first time, at lowest cost. Call him in . . . no obligation.

SEND FOR BOOKLET F7629

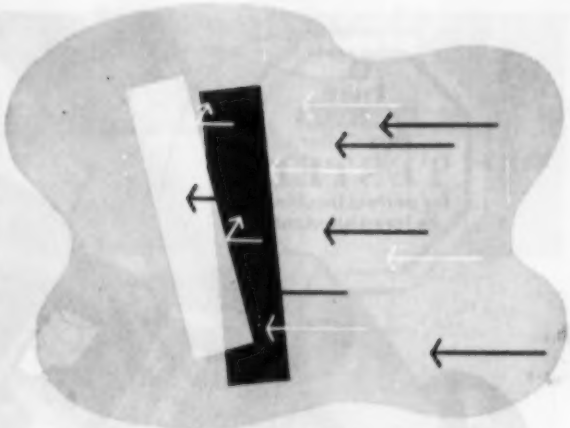
Full of helpful information on jobs such as:

Drum reconditioning • **Descaling**
Salvage cleaning • **Tank interiors**
Paint stripping

Write to OAKITE PRODUCTS, INC.,
Rector St., New York 6, N.Y.

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS • METHODS • SERVICE

Technical Service Representatives in Principal Cities of U. S. & Canada



Radioisotope Laboratory For Oil Industry Opened in Houston!

A radioisotope laboratory solely for supplying the petroleum industry with special tagged compounds has been opened in Houston at 2419 South Boulevard by Tracerlab, Inc. The laboratory will stock and ship on 24-hour notice all the short lived isotopes and standard tagged chemicals now being extensively used, and will thus overcome present serious delivery problems.

Tracerlab has been supplying compounds to oil companies for several years from its Boston, Massachusetts and Richmond, California laboratories. The growing volume of orders has made it practical to establish a special laboratory in a location more convenient for the majority of users.

Many standard compounds utilized by the oil industry are to be packaged and sold under the firm's trade names: TraceSols, which are radioisotope solutions or volatile or gaseous compounds; and TraceOids, which are radioactive isotopes in the form of particulates. These compounds can be shipped on 24-hour notice or less, if the ordering firm's general authorization from the Atomic Energy Commission is on file.

Descriptive sheets on TraceSols and TraceOids, complete with specifications, prices and illustrations of some of the applications, are available on request.

HOUSTON LABORATORY
2419 South Boulevard, Houston, Texas, Tel.: Jackson 9401

130 HIGH STREET, BOSTON 10, MASS.
Tracerlab INC.
2030 WRIGHT AVENUE, RICHMOND 3, CALIF.

WASHINGTON · NEW YORK · HOUSTON · CHICAGO · CLEVELAND · PARIS

For more data on advertised products, use Readers' Service Cards, last page.

Why you cut more pipe more easily with RIDGID Heavy-Duty Pipe Cutters

Extra easy to use—beautifully balanced, you work with least effort . . . high alloy thin blade or heavy-duty cutting wheels roll right thru any pipe, almost burrless cuts . . . perfect tracking.

Extra long service—special malleable housings guaranteed not to warp or break . . . every cutter individually tested before shipment, all 6 sizes—⅛" to 6"; 4-wheel cutters to 4".

For most for your money, buy RIDGID . . . Your local Supply House stocks them for you, gets them to you fast as you need them.

THE RIDGE TOOL COMPANY • ELYRIA, OHIO, U. S. A.

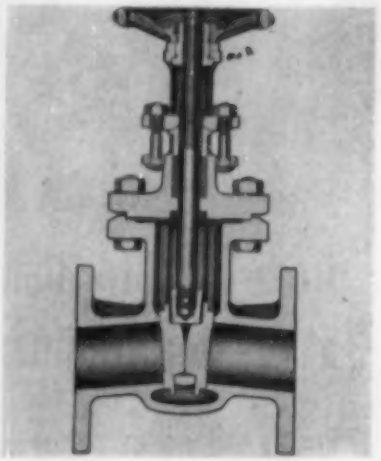
RIDGID
Work-Saver Pipe Tools

New Equipment . . .

of piping, equipment and instruments, to bleed at double block valves, and as freeze drains, trycocks, and sample connections.

The ½-inch valve is priced at $2.95, and the ¾-inch valve at $3.45. These are available FOB, Houston, packed six to a box. For complete details, simply . . .

Circle E6 on Postcard



Alloy Valves

A completely new line of alloy gate, globe, and angle valves has been announced by Crane Company. Outstanding among the many features of the new line are a unique and exclusive split-wedge disc design in the gate valves and an improved disc-stem connection in the globe and angle valves.

The new valves are regularly available in Crane 18-8S Mo stainless steel and Craneloy 20 high nickel, high-chromium stainless steel. The packing used in all valves is Teflon, a product of Du Pont.

The split-wedge disc in the gate valves is made up of two identical, circular discs placed back-to-back in a carrier. The discs have a convex trunnion on the back and an integral circumferential flange which bears on guide slots in the valve body. Excessive force is not required for tight seating because of the uniform distribution of the seating load over both discs. This uniform pressure, plus freedom of the discs to rotate, is highly effective in reducing seat wear and the prevention of galling of the seating surfaces.

Complete details are available on this new development in valves now.

This item supplements Crane Company data on pages 290-291 of The Refinery Catalog, 22nd Edition.

Circle E7 on Postcard

Electric Impactool

A new rotary electric Impactool, with 25 percent more power, has just been developed by Ingersoll-Rand Company to meet the nut-running requirements of modern maintenance in the refining, gasoline and petrochemical industries.

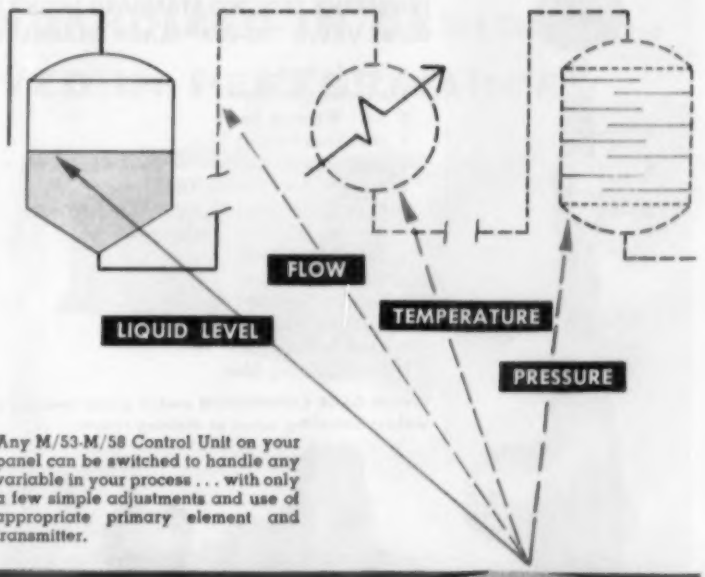
Known as the Size 5U, the tool has a ½-inch drive and weighs only 6¼ pounds. It is designed to carry more power than

No obsolescence for this controller when process requirements change!

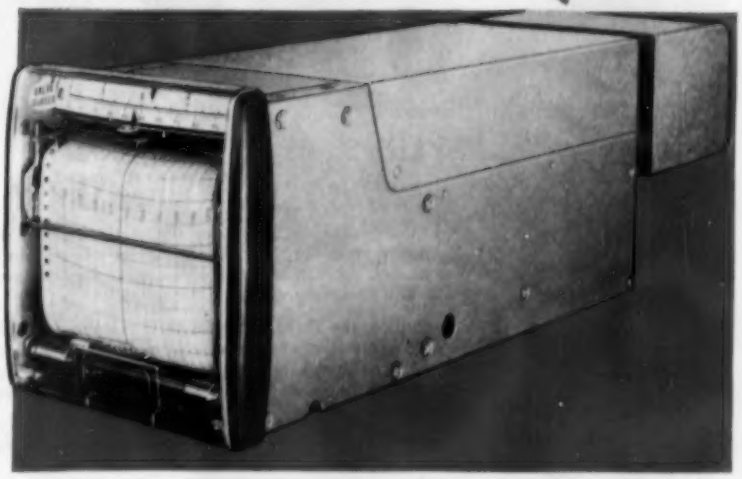
That's right! The Foxboro M/53-M/58 Recorder-Controller is a "universal" instrument, equally adaptable to any process measurement — whether flow, temperature, pressure, liquid level, or other.

All it takes is connection to the proper measurement transmitter having a 3-15 psi pneumatic signal . . . and making the appropriate controller settings. Changes such as adding derivative to reset or proportional control can be made *on the job* without special tools or realignments. You save needless duplication in capital investment . . . save time and trouble in making process revamps . . . and get the unsurpassed performance of M/58 control on every application!

Whether you favor graphic, console, or conventional mounting, you can cut instrument overhead at every stage, step-up efficiency in every operation, with the Foxboro M/53-M/58 Recorder-Controller. Write for complete information. **The Foxboro Company, 742 Neponset Ave., Foxboro, Mass., U.S.A.**



Any M/53-M/58 Control Unit on your panel can be switched to handle any variable in your process . . . with only a few simple adjustments and use of appropriate primary element and transmitter.



OTHER BASIC ECONOMIES

- **Simplified Ordering**
  —complex specification sheets are eliminated.
- **Reduced Stock Inventory**
  —only one type recorder-controller for all control jobs.
- **Reduced Maintenance**
  —fewest parts, rugged design, no diaphragms, highest quality throughout.

FOXBORO
REG. U. S. PAT. OFF.

Consotrol Process Control

FACTORIES IN THE UNITED STATES, CANADA AND ENGLAND

For more data on advertised products, use Readers' Service Cards, last page.

HERE'S WHY

PENBERTHY

GAGE VALVES

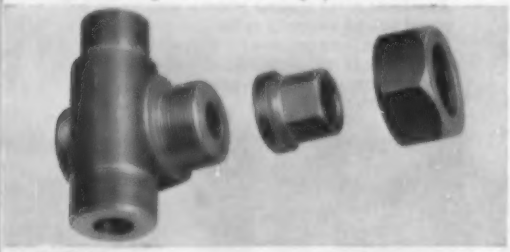
ARE YOUR BEST BUY!

Long, Trouble-Free Service Built-In

PENBERTHY TYPE 300 STANDARD LIQUID LEVEL GAGE VALVE "DU-LUX" BLACK ENAMEL FINISH

- A Steel Locknut
- B Identification Plate
- C Steel Wheel or Lever
- D Steel Stem Packing Nut
- E Stainless Steel Standard or Quick-Closing Stem
- F Stainless Steel Packing Gland
- G High Temperature Resisting Stem Packing
- H Stainless Steel Stem Packing Retainer
- I Forged Steel Body
- J Stainless Steel Ball
- K Stainless Steel Ball Retainer
- L Patented "Floating Shank"
- M Steel Tailpipe
- N Steel Coupling Nut

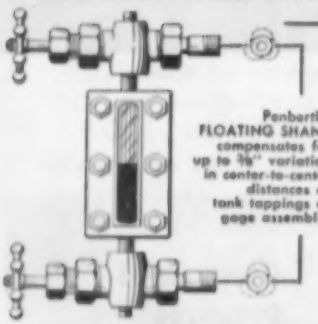
UNION GAGE CONNECTION models permit removal of gage without disturbing valves or draining system.



PLUS... AT NO EXTRA COST... EXCLUSIVE FLOATING SHANK

No other gage valve has all of the quality features of a Penberthy. Features that add up to top performance at lowest cost. You can see that for yourself in the "exploded" view of a Penberthy valve.

In addition, the FLOATING SHANK is a time and labor saving feature that cuts installation and replacement costs by 50% or more. It also eliminates strain, caused by a forced installation, with its subsequent danger to the entire installation.



Penberthy FLOATING SHANK compensates for up to ¾" variation in center-to-center distances of tank tappings or gage assembly.

Try Penberthy Gage Valves on your next installation. See for yourself why they are your best buy. Obtain them through your local supplier or direct. WRITE for Catalog No. 35 showing the complete line . . .

PENBERTHY INJECTOR COMPANY

Division of the Buffalo-Eclipse Corporation

1242 HOLDEN AVENUE • DETROIT 2, MICHIGAN

- GAGES
- EJECTORS
- EDUCTORS
- EXHAUSTERS
- SYPHONS
- ELECTRIC SUMP PUMPS
- CYCLING JET PUMPS
- INJECTORS

There's Certain Satisfaction in Products by PENBERTHY

New Equipment . . .

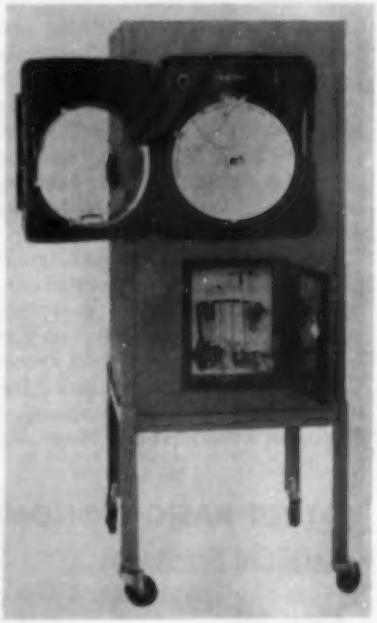
any other ½-inch electric impact tool in its size and weight class. As with other electric impact tools in this series, this newest member is also a multi-purpose tool. With standard attachments which can easily and quickly be applied, it will drill, drive screws, ream, tap, do wire brushing, hole sawing, etc.

Besides additional power, another improvement on the new 5U is a renewable, synthetic rubber bumper which snaps onto the front of the tool housing. This prevents the entrance of dirt around the driver and also protects the housing when the tool is used in tight spots.

Complete details are available on this new development.

This item supplements Ingersoll-Rand Company data on pages 481-488 of The Refinery Catalog, 22nd Edition.

Circle E8 on Postcard



Oxygen Analyzer

Arnold O. Beckman, Inc. is announcing a new development—the Model 2B2B Dissolved Oxygen Analyzer—to meet the requirements of modern industry for a continuous measurement of dissolved oxygen in boiler and other feedwaters.

The Model 2B2B Analyzer consists of a sample flow regulating an ion exchange unit, an analysis unit, and a modified recorder. These components may be enclosed in a cabinet mounted on a portable stand (as illustrated), or they may be panel mounted if desired.

The principle of measurement is based on the oxidation of nitric oxide, NO, in water solution by dissolved oxygen to nitrogen dioxide, NO_2, which in turn reacts with water to form nitric and nitrous acids. In operation, nitric oxide gas is bubbled into the flowing sample to saturation. Any increase in the conductance of the water is due to the products of the reaction of the nitric oxide with dissolved oxygen. At such low concentrations, virtually complete ioniza-

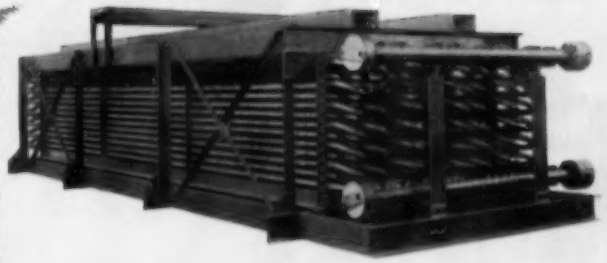
AMMONIA CONDENSERS...

STANDARDIZED IN DESIGN
PROVED IN PERFORMANCE

CASCADE TYPE

for water — ammonia service

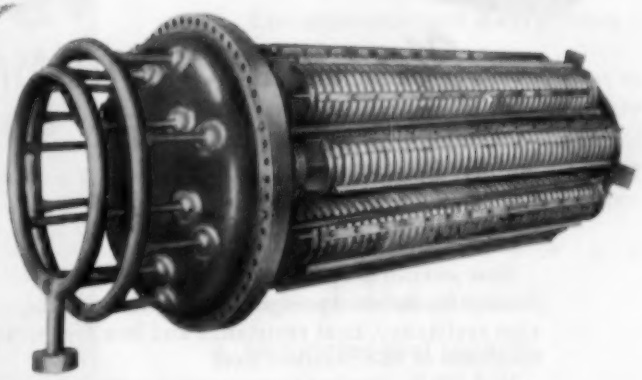
This cascade condenser, operating with water over the outside of the individual zig-zag coils, was designed for an ammonia pressure of 5,200 psig. The unit is furnished complete with frame work and catwalk as well as water distributing piping and necessary troughs. While the unit as shown is wholly constructed of steel, other designs with copper-clad steel or galvanized steel coils and headers are available when heavy corrosion on the water side is expected. This compact, standardized design is promptly available, efficient in use, and easy to maintain.



SHELL-and-COIL TYPE

for ammonia — ammonia service

The coils in this condenser are closely wound nested helicals with manifolds arranged as shown. The shell side design pressure is 165 psig and the coil side 5,200 psig. This unit has proved exceptionally economical to operate and maintain and its standardized construction, eliminating special engineering, assures lowest equipment cost.



Whatever your heat exchanger problem, ask us for recommendations. Our long experience is at your service. The Whitlock Manufacturing Company, 75 South Street, West Hartford 10, Conn. In Canada: Darling Bros., Limited, Montreal.

Whitlock

Designers and builders of bends, coils, condensers, coolers, heat exchangers, heaters, piping, pressure vessels, receivers, reboilers.

For more data on advertised products, use Readers' Service Cards, last page.

New WATSON-STILLMAN 150 LB. STAINLESS STEEL PIPE FITTINGS, *Types 304, 316*

Now you can get performance-proved Watson-Stillman Fittings for standard pressure services that need the corrosion resistance, heat resistance and low temperature toughness of 18-8 Stainless Steel.

W-S 150 lb. Stainless Fittings, rated at 400 psi cold non-shock working pressure and 150 psi steam pressure, are ideal for process piping, refrigeration systems, high temperature liquid and gas piping and other piping systems. They are available in both Screw-End and Socket-Welding Types in sizes ¼" to 2".

The new Watson-Stillman Stainless Steel Fittings will assure you of long, trouble-free service in tough piping applications... will reduce down-time and cut maintenance costs. For full technical information on these fittings write today for Bulletin S-3-55.

Sold Through Leading Distributors

WATSON-STILLMAN FITTINGS DIVISION

H. K. PORTER COMPANY, INC.

Roselle, New Jersey

10

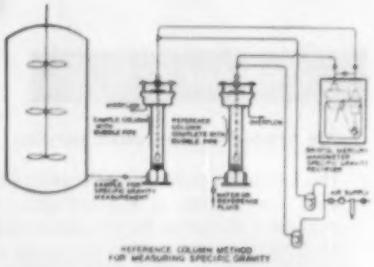
New Equipment...

tion of the acids is realized. The resulting increase in conductance is directly related to the oxygen concentration of the sample.

This new Analyzer has a range of 0-20 parts per billion adjustable to 0-200 parts per billion. The accuracy is within 5 percent of the reading.

For complete details on this new development, simply . . .

Circle E9 on Postcard



REFERENCE COLUMN METHOD FOR MEASURING SPECIFIC GRAVITY

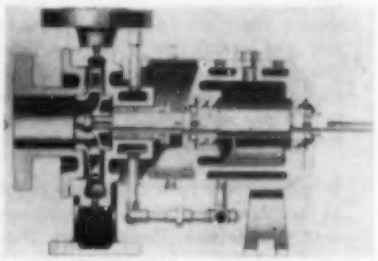
Specific Gravity Meters

A new line of Specific Gravity Meters for liquid solutions, mixtures and slurries has just been announced by the Bristol Company.

These meters operate by comparing the pressure necessary to displace a given head of the liquid sample in a bubbler pipe with the pressure necessary to displace an equivalent head of water.

The new Specific Gravity Meters use a Mercury meter body, with or without counterpoise, and a standard Bristol Series 500 recorder. The recorders can also be equipped to provide automatic control of the specific gravity, in any of five control modes. Complete details are available on this new instrument now. Just . . .

Circle E10 on Postcard



Centrifugal Pumps

Interchangeability of parts is one of the outstanding features of a newly re-engineered and completely integrated line of single stage, end suction, centrifugal pumps announced by Dean Brothers Pumps Inc. This complete pump line has an extensive capacity range. For high temperatures services up to 850 F., three series with a total of 32 pumps are available for capacities as low as 3 gpm or as high as 7000 gpm. The same pumps are available and interchangeable in three parallel or companion series for temperatures up to 350 F.

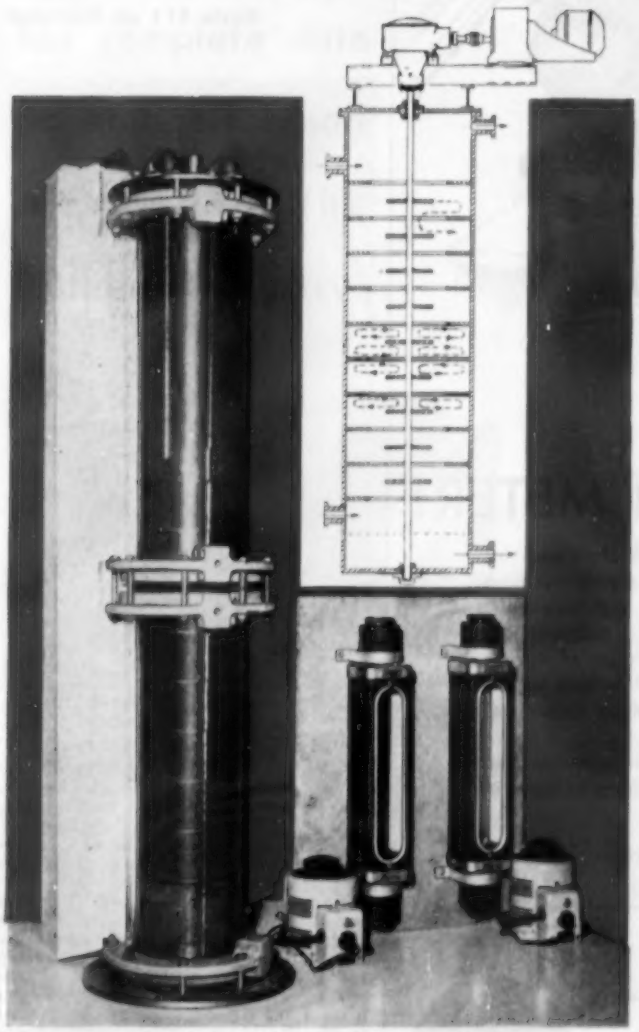
One advantageous feature of interchangeability of parts is the simplicity of

Turbo-Topics

TURBO-MIXER GENERAL AMERICAN TRADE MARK

TURBO-MIXER, a division of

GENERAL AMERICAN TRANSPORTATION CORPORATION



Demonstration model—used to show how the R. D. C column actually operates

Turbo-Mixer R.D.C.* Column

Rotary Disc Contactor for Liquid-Liquid Counter-current Extraction

Six years of data and design development in the laboratory, pilot plants and industry have demonstrated the superior features of this practical counter-current and gravity flow extractor. The R. D. C. extractor offers:

1. **high volumetric efficiency**
2. **high throughput capacity**
3. **simplicity of construction**
4. **no interstage or external settlers**
5. **low power requirements**
6. **flexibility of operation**

May we assist you in the solution of your extractor problems? Our laboratory facilities are available for evaluation of your extraction system.

**Licensed under Shell Development Company patent*

SALES OFFICE: 380 MADISON AVENUE, NEW YORK 17, NEW YORK

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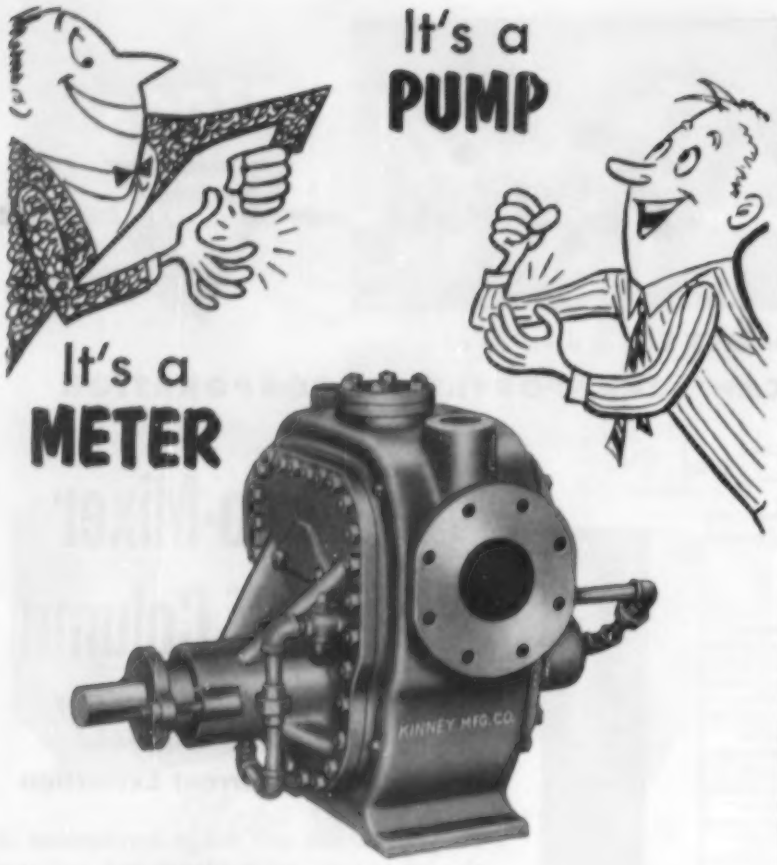


It's **BOTH** PUMP and METER!

The Kinney Model SD Rotating Plunger Pump is often used for pumping viscous materials in storage and bulk plants, handling asphalt and its products. Due to its unusually high volumetric efficiency, this famous pump is often used also for proportioning liquid components and metering fixed percentages of viscous liquids. The simple construction of the Kinney SD, without valves, blades, springs, or vanes, makes this pump virtually maintenance-free even under difficult operating conditions.

SD Pumps are available in capacities from 2 GPM to 3,000 GPM — steam-jacketed in most sizes.

KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY
3506 WASHINGTON STREET • BOSTON 30 • MASS.

☐ Please send Bulletin L51 describing the complete line of Kinney Liquid Pumps.

Name .....
Company .....
Street .....
City ..... State .....

Kinney

New Equipment . . .

replacement parts stocks. For example, in any one series, one Pump Shaft fits all pumps. Likewise, one Stuffing Box Gland, one Seal Ring, and etc. Some additional features of this complete line of pumps are:

- Enclosed cradle
- Drain rim base
- Labyrinth, non-sparking bearing seals
- Rabbetted joints
- Alloy steel studs
- Simplicity of design
- Ease of maintenance

This item supplements Dean Brothers Pumps, Inc. data on page 333 of The Refinery Catalog, 22nd Edition.

Circle E11 on Postcard

Sump Pump

A solution to the problem of quickly removing water from trenches and excavations is now being offered by Schramm, Inc.

The solution, a pneumatic sump is designed with exceptionally large capacity so that de-watering can be quickly accomplished. The penumatic sump pump is preferred for these services because it can be dropped in the water, eliminating priming, and because it can be operated by any 105 or 125 cfm. compressor, which is usually already on the job. This new pump is small and lightweight, easy to transport to the job and requires small storage space when not in use. For a bulletin describing this new pump, simply . . .

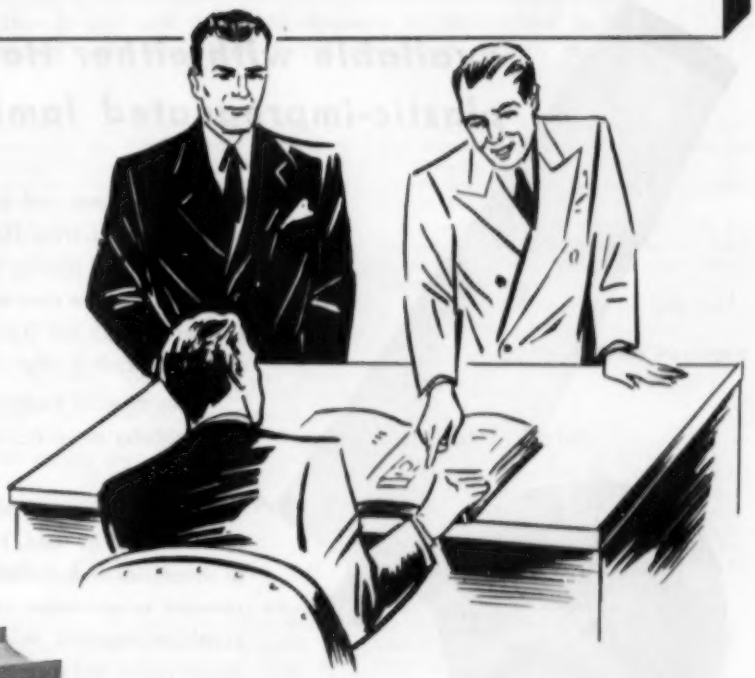
Circle E12 on Postcard

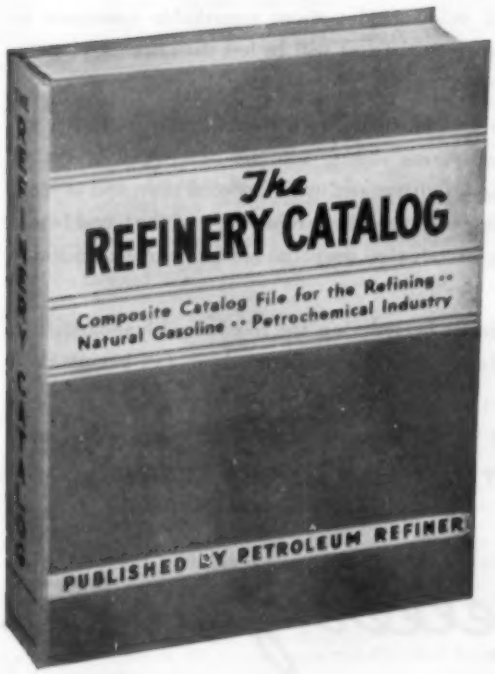
Is PETROLEUM REFINER being passed to you on a routing slip? Your own personal copy is now available at only $2.00 per year. For complete details . . .

Circle E13 on Postcard

Starting a New Project?

Refinery Catalog has complete data on equipment and services for the Refining Industry.

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Reach for your *Refinery Catalog* whenever you're planning a project. Turn to the easy-to-use index and you'll find that most of the known manufacturers have data filed in this universal equipment buyers guide. The current edition carries catalog information on products and services offered by hundreds of manufacturers.

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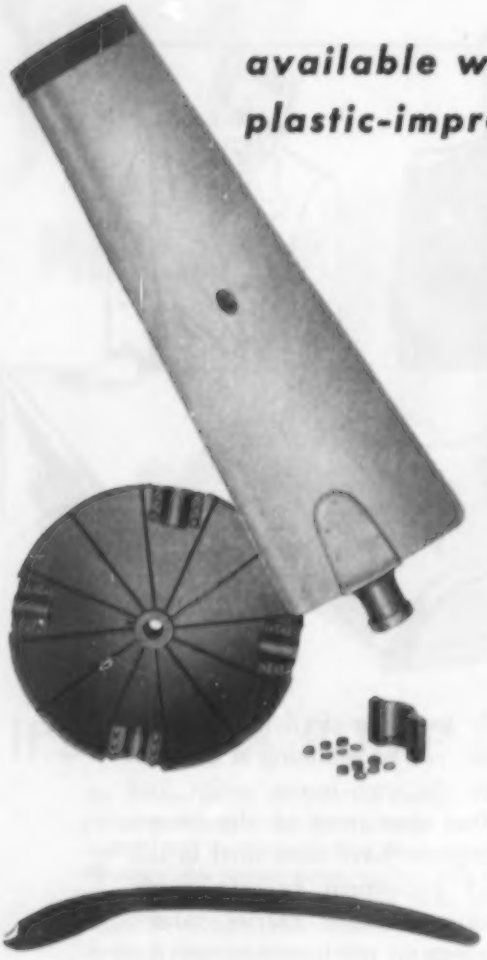
THE UNIVERSAL EQUIPMENT GUIDE FOR REFINERY BUYERS

REFINERY CATALOG

P. O. BOX 2608 • HOUSTON 1, TEXAS

For more data on advertised products, use Readers' Service Cards, last page.

New tapered-blade design boosts efficiency, increases strength of Hartzell cooling tower fans



This cross section cut from a laminated Hartzite plastic blade shows the heavy reinforcing rib along the leading edge.

available with either Hartzite plastic or new plastic-impregnated laminated wood blades

Greater efficiency and increased rigidity which reduces sag to a minimum result from Hartzell's new tapered-blade design. Blades now used on all cooling tower and heat exchanger fans in 14 to 22 foot diameters are considerably thicker at the shank than at the tip. Further strength and rigidity is provided by a rib-like reinforcement along the leading edge of the blade.

Two types of blades are available in the new design — Hartzite plastic blades as on the older designs and new plastic-impregnated wood blades.

For maximum durability and length of life, Hartzite plastic blades should be used. Fabric-reinforced Hartzite has been proved in thousands of installations since 1941 as the blade material most resistant to corrosion, vibration and abrasion. However, the new plastic-impregnated wood blades show remarkable resistance to deterioration and their initial cost will be less than that of Hartzite blades.

Both blades are of laminated construction. Hartzite blades are laminated of cured plastic sheets, and the new wood blades of 1/16" maple or birch impregnated with a special resin and covered with a plastic-setting coating. The leading edge of the wood blades is covered with an aircraft-type neoprene boot to increase resistance to abrasion.

Taper is achieved by reducing the number of laminations. A blade from a 14 foot assembly tapers from 1½" (14 laminations) at the shank to ¼" (3 laminations) at the tip.

For complete details on these rugged new fans, write today for your free copy of Bulletin A-111A.

HARTZELL

propeller fan co.

Div. of Castle Hills Corp.

Please send me a copy of Bulletin A-111A, "Hartzell Cooling Tower and Heat Exchanger Fans."

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Company _____

Street & Number _____

City & State _____

If student, check here for special information ☐

Dept. K

PIQUA, OHIO

PROPELLER-TYPE FANS • BLOWERS
ROOF VENTILATORS • UNIT HEATERS

ENGINEERING OFFICES IN PRINCIPAL CITIES

What's New in Manufacturers' Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Reader Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card. Requests are transmitted to the manufacturer as soon as received by us for mailing of desired information directly to you.

Chemical Bulletins

The Nitrogen division of Allied Chemical & Dye Corporation has recently released a series of informative and well illustrated brochures on some of its products. Each of these brochures includes a description, list of uses, physical properties, chemical properties, shipping methods, handling and storage, and specifications. The following brochures are available now:

A1—Ammonia Liquor
B1—Anhydrous Ammonia
C1—Ammonium Nitrate Solutions
D1—Ethanolamines
E1—Ethylene Oxide
G1—Ethylene Glycol
H1—Diethylene Glycol
K1—Methanol
L1—Nitrate of Soda
M1—Sulphate of Ammonia
P1—Urea

In order to receive a copy of any of these informative brochures simply write the identifying letter and numeral on the back of the Reader Service card and . . .

Circle E14 on Postcard

Molybdenum Bulletin

Climax Molybdenum Company has just released a bulletin on the "Thermodynamic Properties of Molybdenum Compounds." This is a collection of thermodynamic values for molybdenum and its more important compounds. It is based on a comprehensive search of the literature of the past 20 years and assures virtually complete coverage of all available pertinent data.

Copies of this extremely informative bulletin are available without charge now. Just . . .

Circle E15 on Postcard

Precipitation Bulletin

Research-Cottrell, Inc., has published a 28-page bulletin on its electrical precipitation equipment. The bulletin describes the general principles of electrical precipitation as well as its chief applications, such as power plants, oil refineries, and carbon black plants.

Installation photographs and diagrams supplement the text. To receive your copy of this informative bulletin, just . . .

Circle E16 on Postcard

Welding Bulletin

A 10-page bulletin issued by Arcos Corporation describes a new welding technique known as the EB Weld Insert process. As illustrated in the bulletin, this process, developed by the Electric Boat division of General Dynamics Corporation, permits deposition of a root pass which produces a smooth and uniform weld surface even though the actual welding is done on one side only. The process and the insert used with the process are essentially suitable for the butt welding of stainless and alloy steel pipe, both seamless and welded.

Information in the bulletin covers applications, compositions, dimensions and detailed specifications. Complete step-by-step information, with sketches and photographs, explains how to use the insert and process. Also listed are recommended filler metals for finish welding.

To receive your copy of this bulletin, simply . . .

Circle E17 on Postcard

Liquid Chillers

Packaged Liquid Chillers is a subject of a new bulletin now being offered by Worthington Corporation. The Worthington line of liquid chillers described and illustrated in this bulletin are designed for air conditioning and industrial applications and range from 7½ to 150 hp. in a variety of models and combinations.

Pictorially and graphically illustrated, the new bulletin gives specifications, dimensions and applications of variously sized liquid chillers which are designed to offer such advantages as low-cost operation, ease of installation, trouble free operation.

For your copy of this new bulletin, simply . . .

Circle E18 on Postcard

Clad Steel Bulletin

Of particular interest to the design engineers and construction personnel is a new bulletin just issued by Lukens Steel Company. It presents dollars and cents facts about the economy possible through the use of clad steel plates. Entitled "Price Comparisons—Clad Steels vs. Solid High Alloys," the booklet discusses 16 standard alloy claddings on a variety of backing steels.

Copies of this report are available without charge now. Simply . . .

Circle E19 on Postcard

Jet Syphon Bulletin

A new bulletin describing Steam and Air Jet Syphons has recently been published by Schutte and Koerting Company. This bulletin treats the application, construction, operation and performance of Jet Syphons which utilize the pressure energy of steam or air to pump, heat and mix liquids, gases and slurries. Included in the bulletin are 17 tables on suction capacities, steam consumption, operating pressures, and sizes and dimensions.

A complete line of special purpose Jet Syphons is also described, including lead-lined, glass, special alloy and other corrosion resistant types.

To receive your copy of the informative booklet, just . . .

Circle E20 on Postcard

Control Bulletin

A bulletin describing the New Series 60 electric proportional control for Speedomax Type G, Speedomax Type H and Miscromax controllers is now being made available by Leeds & Northrup Company. The bulletin fully describes the control series 60 units as well as suggesting applications for these units. Also described in the bulletin are position adjusting type (PAT), duration-adjusting type (DAT), and proportional type controls.

In order to receive your copy of this most informative bulletin, simply . . .

Circle E21 on Postcard

Alloy Steel Bulletin

Recently released by International Nickel Company is Bulletin A-61, a 16-page booklet describing high strength low alloy steels. Included in this bulletin are their physical characteristics, their corrosion resistance, and a section on how they are formed and worked as well as the design factors involved in their use. Applications in many fields are given. Also included is a section on the economics of applications of these metals.

To receive your copy of this informative booklet, simply . . .

Circle E22 on Postcard

Hoist Bulletin

An 8-page, two-color bulletin describing the company's complete line of spur-gear hoists is now being made available by Coffing Hoist Company.

The bulletin includes pictures, cut-away drawings, descriptions and specifications of the entire YC and YCT lines. In addition to standard single and multiple-chain units, models for specialized applications are shown. Various types of trollys, both plain and geared, are also illustrated. This new and informative bulletin is available now. Simply . . .

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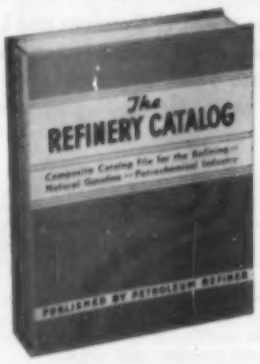
Advertisers in February Issue



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2. For more data on Advertised Products and Services, circle on card the actual page number of the advertisement as listed in the Advertisers' Index on the preceding page.
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BOX 2608

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Circle code number for more data on "New Equipment" editorial items

Circle page number for more information on ADVERTISED products

PETROLEUM REFINER Readers' Service Card — **February, 1955, Issue***

EDITORIAL ITEMS—Circle code numbers on which more information desired:

E1 E13	E2 E14	E3 E15	E4 E16	E5 E17	E6 E18	E7 E19	E8 E20	E9 E21	E10 E22	E11 E23	E12

ADVERTISEMENTS—Circle page number of ad for more product information:

1	2	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
84	85	86	87	88	89	90	91	92	94	167	169	171	173	174	175	176	177	178	181
182	183	184	185	186	187	188	189	190	191	192	194	196	198	199	200	201	202	203	204
205	206	207	208	209	210a	210b	211	213	215	216	216	216	217	218	219	220	221	222	224
225	226	227	228a	228b	229	230a	230b	231	238	234	235	236	237	238a	238b	239a	239b	240a	240b
241a	241b	243	244	245	246a	246b	247	248	249	250a	250b	251	253a	253b	253c	253	254	255a	255b
255c	256d	256	258	260	261	262	263a	263b	264	265	266	267	268	269	270	271	272	277	278

Name (Please Print) _____

Company _____ Position _____

Address _____

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for more information

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2. For more data on Advertised Products and Services, circle on card the actual page number of the advertisement as listed in the Advertisers' Index on the preceding page.
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ADVERTISEMENTS—Circle page number of ad for more product information:

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44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
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First Class Permit No. 7 (Sec. 34.9, P. L. & R.), Houston, Texas

PETROLEUM
REFINER

BOX 2608

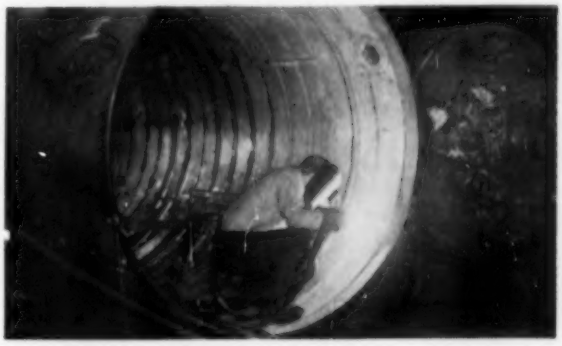
HOUSTON 1, TEXAS, U. S. A.

Quick–Easy

Use these cards to help keep informed on what's new . . . for more job-help information on equipment and services

what GRAVER craftsmanship means:

Applied Research! These Graver engineers are running distortion tests in the welding laboratory. Our research in welding techniques has resulted in numerous advances in the industry, including another Graver "first," the automatic vertical-seam field welder.



Expert Welding! This skilled Graver craftsman is busy welding special alloy strips to the inside of a large saturation absorber. Graver utilizes every modern technique in manual and automatic welding. Graver also employs the latest inspection equipment and procedures to insure that every storage tank and pressure vessel—be it of stainless, aluminum, alloy, clad, or of carbon steel—measure up to the strictest standards.

The Finished Product! This huge 106-ton fractionator tower measures 11′ 6″ I.D. by 120′ 2″ in height. It evidences the painstaking research, experienced ability, and thorough inspections that are part of every Graver product.

GRAVER ... *Specialists in the fabrication of towers, tanks, pressure vessels*

GRAVER TANK & MFG. CO., INC.

East Chicago, Indiana

CHICAGO • NEW YORK • PHILADELPHIA • EDGE MOOR, DEL. • ATLANTA • CATASAUQUA, PA. • PITTSBURGH • CLEVELAND • DETROIT • TULSA • SAND SPRINGS, OKLA. • HOUSTON • ODESSA, TEXAS • CASPER, WYO. • LOS ANGELES • FONTANA, CAL. • SAN FRANCISCO

McDONALD LINE STRAINERS

Advanced design — rugged construction for a full measure of dependability

TOP CLEAN-OUT STRAINERS WITH IRON BODY CAP AND YOKE, AND BRONZE STRAINER UNIT

PLATE 963 — Especially designed for quick, easy cleaning. Yoke is attached and lowered over body during cleaning process to eliminate the possibility of dropping or misplacement.

The strainer unit is bronze with a perforated brass cylinder. Strainer is available in 1/16", 1/8", 3/16" and 1/4" perforations. 1/16", standard for use with gasoline and kerosene, is furnished unless otherwise requested. 1/32" perforations can be furnished on request.

2" and 3" sizes available

PLATE 963-F—Design of strainer eliminates restriction. Identical in construction to Plate 963 except for flanged ends. 3" and 4" sizes available.

Strainer Unit and Top Cap. This type unit used in Plates 963 and 963-F. Furnished with female thread for attaching to male thread of cap, permitting removal of strainer unit from cap during cleaning if so desired.

BOTTOM CLEAN-OUT LINE STRAINERS

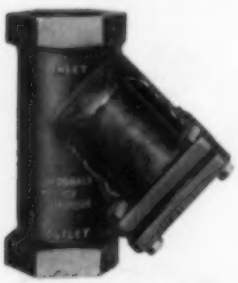


PLATE 914—Bolted Cap Type - cleaned by removing four bolts and lifting off the cap to which the strainer is attached. Furnished with iron body and perforated brass cylinder which acts as strainer. Strainer unit is heavily constructed to eliminate breakage. Perforated brass strainer is available in 1/16" (furnished unless otherwise specified), 1/8", 3/16" and 1/4" perforations.

Sizes 1½", 2", 2½" and 3"

PLATE 914-Y—Similar in construction to Plate 914 except for its cap and yoke design (see illustration). This type is preferred by many from a convenience standpoint. 2" and 3" sizes available

BELL STRAINER

PLATE 907—All bronze strainer used on end of suction when unloading tank cars. The McDonald Bell Strainer prevents sediment from being pumped into tank. Constructed with special rust-proof screen.

Sizes 2", 2½", and 3".

STRAINER CONNECTION

PLATE 806—Used when unloading tank cars from bottom outlet. Strains oil or gasoline before it passes through pump. Strainer is held firmly in place by a guide post on top cap. Removal of top cap removes strainer for cleaning.

Sizes 2", 2½", 3" and 4". Available in black or galvanized.

EST. 1856 McDonald

A. Y. McDONALD MFG. CO.

Dubuque, Iowa